Sustainability impact assessment for improved food security

The benefit of local stakeholder participation

– The case of four villages in Dodoma and Morogoro Region, Tanzania –

DISSERTATION

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Summary

Food security remains a major challenge in Sub-Saharan Africa. Sustainable agricultural development is fundamental for food security and poverty alleviation, notably in developing countries. Many development initiatives focus on enhancing smallholder production because the majority of poor people in developing countries live in rural areas where agriculture is the main source of livelihood. However, the consequences of these development initiatives are often diverse, having intended effects as well as unforeseen adverse impacts. Therefore, there is a need to assess development strategies/projects prior to their implementation to reduce the risk of possible negative impacts and to allow for adjustments, if necessary. This can be achieved by applying ex-ante sustainability impact assessment.

The theoretical discourse on ex-ante sustainability impact assessment is comprehensive, emphasising the equal integration of all three sustainability dimensions (social, economic and environmental), the active involvement of stakeholders at every step of the assessment process and a focus on exchange and learning among the involved stakeholders. In practice, local communities are rarely involved in ex-ante impact assessment. Moreover, despite a strong emphasis on their involvement in theory, there remains a lack of easily applicable frameworks for sustainability impact assessment. Hence, there are only few concrete case studies having analysed the value added by applying sustainability impact assessment with local stakeholders and its benefit for planning agricultural measures to enhance food security and sustainable development. This PhD thesis closes the gap by developing and applying an ex-ante impact assessment approach that is based upon the Framework for Participatory Impact Assessment (FoPIA) method and is applicable at small-scale farmer level in the development context. The framework was applied to assess the sustainability of upgrading strategies along the farmers' food value chains to improve food security in rural Tanzania at four contrasting case study villages in the semi-arid Dodoma Region and the semi-humid Morogoro Region.

This thesis first (chapter 1) provides an overview of the food security situation of smallholders in developing countries, with an emphasis on Tanzania. The research objective, the hypothesis as well as the study area are presented. In the second part (chapter 2), an overview of the development pathway of impact assessment is given, starting with the first initiatives of environmental impact assessments and proceeding to today's existing manifold impact assessment types (chapter 2.1). Furthermore, social learning theory (chapter 2.2.1) and planning theory (chapter 2.2.2) are presented in further detail, as the theoretical foundations of this PhD thesis. The pathway from disciplinary all the way to transdisciplinary research (chapter 2.3) is illustrated to embed the thesis' methodological approach, before the research design is presented in chapter 3. The results section (chapter 4) comprises three peer-reviewed journal articles, with another fourth review article included in the annexe. Chapter 5 provides the overall conclusion of this research.

The author of this thesis is the first author of four publications in four different international peer-reviewed journals. The articles have been elaborated in the following chronological order:

The first publication is a review article called *Methods to assess farming sustainability in developing countries*. This article was not used in the main text of this dissertation due to its review character. With the resolution 12/2015.13 taken on 16th December 2015 by the board of the faculty of life sciences (Thaer-Institute, Humboldt-Universität zu Berlin) it was decided that review articles cannot further be counted as one of the required publications within a cumulative dissertation. Nevertheless, this article was integrated in the annexe section (Annexe 1), because based upon the analysis conducted in the review, the methodological approach that was applied in this thesis was chosen. This review provides a detailed insight into the state of the art of ex-ante sustainability impact assessment. First, a theoretical discourse of ex-ante impact assessment is presented. Altogether, ten methodological approaches were analysed regarding the theoretical background and requirements of sustainability impact assessment.

The first paper of this dissertation, *Developing community-based food security criteria in rural Tanzania* (Chapter 4.1) presents the first part of the methodological framework FoPIA and shows in detail the elaboration of the food security criteria with local farmers, which were later used during the impact assessment process. The local understanding of food security was analysed and a set of food security criteria was derived in a participatory process. The criteria covered the three dimensions of sustainability (social, economic and environmental), while simultaneously representing the food security dimensions (availability, access, utilization and stability) showing the holistic view of the farmers regarding food security within their local context.

The second paper of this dissertation, *Sustainability impact assessment to improve food security of smallholders in Tanzania* (Chapter 4.2) presents the entire FoPIA framework and the impact assessment results of proposed agricultural upgrading strategies on the elaborated food security criteria (presented in the first paper [Chapter 4.1]) in all four case study villages. The positive impacts were found to be mainly related and attributed to increased agricultural production. Several negative impacts were also indicated by the farmers, such as increased workload, loss of traditional knowledge and social conflicts in the family and community. In conclusion, the participatory impact assessment with FoPIA with farmers allowed a site-specific analysis of the various positive and negative impacts of agricultural upgrading strategies on social life, the economy and the environment.

The third paper of this dissertation, *Participatory impact assessment: Bridging the gap between scientists' theory and farmers' practice* (Chapter 4.3) presents the results of both the farmers' and the scientists' impact assessments. The results show that farmers and scientists have considerably different views on the impacts of proposed agricultural upgrading strategies. It is concluded that ex-ante impact assessment is a valuable tool to assess impacts from different angles, facilitating insights into the complex socio-environmental context of local communities. It allows for corrective measures during planning and prior to implementation, which help in adapting planned upgrading strategies to ultimately benefit the local community.

Zusammenfassung

Die Ernährungssicherung der Bevölkerung im ländlichen Raum in Sub-Sahara Afrika ist eine der dringlichsten Herausforderungen unserer Zeit. Der Großteil der Bevölkerung ist von der eigenen landwirtschaftlichen Produktion für die Ernährung und die Existenzsicherung abhängig. Eine nachhaltige Entwicklung kleinbäuerlicher Landwirtschaft ist daher eine Grundvoraussetzung für Ernährungssicherung und Armutsbekämpfung. Eine Vielzahl von Entwicklungsmaßnahmen zielt auf die Verbesserung der Agrarproduktion von Kleinbauern und Kleinbäuerinnen ab, um die Ernährungssituation zu verbessern. Die Konsequenzen dieser Entwicklungsmaßnahmen sind oft vielfältig; neben gewollten, intendierten Wirkungen, können sich Entwicklungsmaßnahmen auch negativ auswirken. Daher ist es essentiell ein *ex-ante impact assessment* vor der Umsetzung durchzuführen, um eventuelle negative Auswirkungen frühzeitig zu identifizieren und die geplanten Maßnahmen dementsprechend anzupassen.

Der theoretische Diskurs hinsichtlich der Charakteristika von *ex-ante sustainability impact assessment* ist sehr umfassend erarbeitet. Hier werden vor allem die gleichwertige Integration der drei Nachhaltigkeitsdimensionen (Soziales, Wirtschaft und Ökologie), die aktive Partizipation verschiedener Stakeholder auf unterschiedlichen Ebenen und der Austausch- und Lernprozess in den Mittelpunkt gerückt. In der Praxis wird die lokale Bevölkerung hingegen selten in ex-ante Wirkungsanalysen von geplanten Entwicklungsmaßnahmen involviert. Auch wenn in *sustainability impact assessment* ein interaktiver Einbezug der lokalen Bevölkerung unterstrichen wird, existieren kaum einfach anwendbare methodische Vorgehensweisen, um dies durchzuführen. Zudem gibt es bisher nur wenige Fallstudien, die das Einbeziehen von lokalen Stakeholdern beschreiben, systematisch analysieren und den Mehrwert für die Planung von landwirtschaftlichen Entwicklungsmaßnahmen herausstellen. Die vorliegende Arbeit hat zum Ziel diese Forschungslücke zu schließen. Im Rahmen der Dissertation wurde ein methodischer Ansatz für ein *ex-ante sustainability impact assessment* für die Anwendung mit der lokalen Bevölkerung entwickelt. Diese Methode wurde angewendet, um die positiven und negativen Auswirkungen von geplanten landwirtschaftlichen Entwicklungsmaßnahmen aus Sicht der Kleinbauern und Kleinbäuerinnen zu analysieren. Die Forschung wurde in vier Dörfern im semi-ariden Dodoma und im semi-humiden Morogoro in Tansania durchgeführt.

Im ersten Kapitel wird ein allgemeiner Überblick zur Ernährungssituation in Entwicklungsländern, insbesondere in Tansania, und zum Stand von *ex-ante impact assessment* im Rahmen von landwirtschaftlichen Entwicklungsprojekten gegeben. Die Forschungsfrage und Hypothese werden vorgestellt. Im zweiten Kapitel wird die Entwicklung von *impact assessment* präsentiert; von den ersten Umweltverträglichkeitsstudien hin zu den heute anerkannten Ansätzen des *impact*

assessments (2.1.). Des Weiteren werden zwei Theorien dargestellt auf denen die vorliegende Arbeit aufbaut: *Social Learning Theory* (2.2.1) und *Planning Theory* (2.2.2). Der in der Dissertation angewandte methodische Ansatz wird in einem Entwicklungsdiskurs von disziplinärer Forschung hin zu transdisziplinärer Forschung eingebettet (2.3). Das Forschungsdesign wird im dritten Kapitel dargestellt. Die Forschungsergebnisse, die in drei wissenschaftlichen Beiträgen veröffentlicht worden sind, finden sich in Kapitel vier wieder. In Kapitel fünf erfolgt die Zusammenfassung der wissenschaftlichen Ergebnisse.

Die Autorin der vorliegenden Dissertation ist Erstautorin von vier Publikationen, die in folgender chronologischer Abfolge erarbeitet worden sind:

Die erste Publikation ist ein Übersichtsartikel, *Methods to assess farming sustainability in developing countries*. *A review.* Dieser wurde nicht im Haupttext der Dissertation verwendet. Mit dem vom erweiterten Fakultätsrat der Lebenswissenschaftlichen Fakultät gefällten Beschluss 12/2015.13 vom 16.12.2015 wird ein Übersichtsartikel (*Review*) als Bestandteil einer kumulativen Dissertation nicht mehr anerkannt. Nichtsdestotrotz wurde dieser Artikel im Anhang eingefügt, denn auf Basis der darin durchgeführten Analyse wurde der methodische Ansatz für das *impact assessment* der vorliegenden Forschungsarbeit ausgewählt. Der *Review*-Artikel beschreibt den theoretischen Diskurs von *sustainability impact assessment*, der mit den in der Praxis angewandten Modellen und Methoden verglichen wird.

Der erste Artikel der Dissertation, *Developing community- based food security criteria in rural Tanzania* (4.1) stellt den ersten Teil des in der vorliegenden Arbeit angewandten methodischen Ansatzes dar und zeigt im Detail die partizipative Erarbeitung von *Food Security*-Kriterien, die später im *ex-ante sustainability impact assessment* für die Bewertung der landwirtschaftlichen Entwicklungsmaßnahmen angewandt worden sind. Die Kriterien decken die drei Nachhaltigkeitsdimensionen als auch die vier Ernährungssicherungsdimensionen ab. Dies zeigt den allumfassenden, holistischen Blick, den die Kleinbauern und Kleinbäuerinnen auf ihre Ernährungssituation haben.

Der zweite Artikel der Dissertation, *Sustainability impact assessment to improve food security of smallholders in Tanzania* (4.2) stellt den gesamten methodischen Rahmen wie dieser in den vier Dörfern angewendet wurde sowie die *impact assessment*-Ergebnisse dar. Die als positiv angegebenen Wirkungen der geplanten Entwicklungsmaßnahmen beziehen sich insbesondere auf eine landwirtschaftliche Produktionserhöhung. Einige negative Auswirkungen, wie das erhöhte Arbeitsaufkommen, Verlust von traditionellem Wissen und soziale Konflikte wurden ebenso angegeben. Die Ergebnisse zeigen, dass *impact assessment* Einblick in angenommene positive und negative Auswirkungen von geplanten landwirtschaftlichen Entwicklungsmaßnahmen auf das soziale Leben, die lokale Wirtschaft und die Umwelt ermöglicht.

In der dritten Publikation der Dissertation, *Participatory impact assessment: Bridging the gap between scientists' theory and farmers' practice* (4.3) werden die *impact assessment*-Ergebnisse von Wissenschaftlern und der lokalen Bevölkerung dargestellt. Die Ergebnisse zeigen, dass Wissenschaftler und kleinbäuerliche Produzent/innen durchaus unterschiedlich die positiven und negativen Auswirkungen von geplanten Entwicklungsmaßnahmen interpretieren. *Ex-ante sustainability impact assessment* ist ein wertvoller Ansatz, um Auswirkungen von Entwicklungsmaßnahmen aus unterschiedlicher Perspektive zu interpretieren. Geplante Maßnahmen können somit vor ihrer Umsetzung angepasst werden, um einen wirklichen Mehrwert für die Verbesserung der Ernährungssituation im lokalen Kontext zu erreichen.

I Content

II List of figures

III List of pictures

IV List of publications

This dissertation is based on the following four peer-reviewed publications. The following numbering reflects the chronological order in which the journal articles were elaborated:

Annexe 1

Journal: Agronomy for Sustainable Development

(Impact Factor 2015: 4.141)

Schindler, J., Graef, F., & König, H. J. (2015). Methods to assess farming sustainability in developing countries. A review. *Agronomy for Sustainable Development*, 1-15, doi:10.1007/s13593-015-0305-2.

1st Paper of this dissertation

Journal: Food Security: The Science, Sociology and Economics of Food Production and Access to Food

(Impact Factor 2015: 1.557)

Schindler, J., Graef, F., König, H. J., & Mchau, D. (2016). Developing community-based food security criteria in rural Tanzania. [journal article]. *Food Security*, 1-14, doi:10.1007/s12571-016-0627-1.

2nd Paper of this dissertation

Journal: Environmental Impact Assessment Review

(Impact Factor 2015: 2.922)

Schindler, J., Graef, F., König, H. J., Mchau, D., Saidia, P., & Sieber, S. (2016). Sustainability impact assessment to improve food security of smallholders in Tanzania. *Environmental Impact Assessment Review, 60*, 52-63, doi:10.1016/j.eiar.2016.04.006.

3rd Paper of this dissertation

Journal: Agricultural Systems

(Impact Factor 2015: 2.867)

Schindler, J., Graef, F., & König, H. J. (2016). Participatory impact assessment: Bridging the gap between scientists' theory and farmers' practice. *Agricultural Systems, 148*, 38-43, doi:http://dx.doi.org/10.1016/j.agsy.2016.07.002.

V Co-authorship of further peer-reviewed papers during the PhD course

Reif, C., Lana, M., Graef, F., Dietrich, O., **Schindler, J**., Helming, K., et al. (2015). Combining analytical methods for assessing food security across the food value chain: A conceptual integrated approach. Outlook on Agriculture, 44(1), 11-18, doi:10.5367/oa.2015.0193.

Graef, F., I. Schneider, A. Fasse, J. U. Germer, E. Gevorgyan, F. Haule, H. Hoffmann, F. C. Kahimba, L. Kashaga, L. Kissoly, C. Lambert, M. Lana, H. F. Mahoo, B. Makoko, S. H. Mbaga, A. Mmbughu, S. Mkangwa, L. Mrosso, K. D. Mutabazi, L. Mwinuka, H. Ngazi, E. Nkonya, S. Said, A. Schaffert, M. P. Schäfer, **J. Schindler**, S. Sieber, M. Swamila, H. M. Welp, L. William and Y. M. Yustas, (2015). Assessment of upgrading strategies to improve regional food systems in Tanzania: Food processing, waste management and bioenergy, and income generation. Outlook on Agriculture 44, 179-186. doi:10.5367/oa.2015.0209.

Graef, F., I. Schneider, A. Fasse, J. U. Germer, E. Gevorgyan, F. Haule, H. Hoffmann, F. C. Kahimba, L. Kashaga, L. Kissoly, C. Lambert, M. Lana, H. F. Mahoo, B. Makoko, S. H. Mbaga, A. Mmbughu, S. Mkangwa, L. Mrosso, K. D. Mutabazi, L. Mwinuka, H. Ngazi, E. Nkonya, C. Reif, S. Said, A. Schaffert, M. P. Schäfer, **J. Schindler**, S. Sieber, M. Swamila, H. M. Welp, L. William and Y. M. Yustas (2015). Natural resource management and crop production strategies to improve regional food systems in Tanzania. Outlook on Agriculture 44, 159-167. doi:10.5367/oa.2015.0206.

Mwinuka, L., Graef, F., Mutabazi, K., & **Schindler, J.** (2016). Agri-food value chains upgrading strategies choices: a participatory smallholder farmer centred approach. *International Journal of Value Chain Management, submitted*.

Graef, F., Uckert, G., **Schindler, J.,** König, H. J., Mbwana, H. A., Fasse, A., et al. (2017). Expert-based ex-ante assessments of potential social, ecological, and economic impacts of upgrading strategies for improving food security in rural Tanzania using the ScalA-FS approach. [Article in Press]. *Food Security*, 1-16, doi:10.1007/s12571-016-0639-x.

Uckert, G., Graef, F., Fasse, A., Germer, J. U., Hoffmann, H., Kahimba, F. C., Kashaga, R.A.L. , Kissoly, L. , Lambert, C., Mahoo, H. F., Makoko, B., Mbaga, S.H., Mrosso, L. , Mutabazi, K. D. l, Mwinuka, L. , Schäfer, M.P, **Schindler, J.**, Sieber, S. , Yustas, Y. M. (2016). ScalA-FS: Expert-based ex-ante assessment of potential social, ecological, and economic impacts of upgrading strategies for improving food security in rural Tanzania using ScalA-FS approach. *Food Security: The Science, Sociology and Economics of Food Production and Access to Food, submitted*.

König, H. J., F. Graef, **J. Schindler**, A. Fasse, K. Mutabazi, C. Lambert, P. Ngwenya, G. Uckert, H. Mahoo, F. Hattermann and S. Sieber (2016). Combining participatory, qualitative and quantitative methods for impact assessment of food value chains: an integrated framework. *Food Security: The Science, Sociology and Economics of Food Production and Access to Food accepted.*

VI Abbreviations and acronyms

Aver.	Average
BMBF	Bundesministerium für Bildung und Forschung (German Federal Ministry of Education and Research)
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (German Federal Ministry for Economic Cooperation and Development)
DESIRE-DSS	Decision Support Systems developed within the EU-DESIRE research project
DPSIR	Driving forces, Pressures, States, Impacts, Responses
EC	European Commission
EIARD	European Initiative for Agricultural Research for Development
FAO	Food and Agriculture Organization
FIELD	Field-scale Interactions, use Efficiencies and Long-Term soil fertility Development
FoPIA	Framework for Participatory Impact Assessment
FARMSIM	Farming Simulation, FARMSIM is a 3D Computer Simulation programme
GIRA	Interdisciplinary Group for Appropriate Rural Technology
GIZ	Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
HAFL	Hochschule für Agrar-, Forst- und Lebensmittelwissenschaften (School of Agricultural, Forest and Food Sciences)
HEAPSIM	Computer model simulation
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
IAIA	International Association for Impact Assessment
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
INRA	Institut national de la recherche agronomique (National Institute for Agricultural Research)
LIVSIM	Computer model simulation for Mere cattle in Mali
MESMIS	Marco para la Evaluación de Sistemas de Manejo de recursos naturales incorporando Indicadores de Sustentabilidad (Framework for the Evaluation of Natural Resource Management Systems Incorporating Sustainability Indicators)
NBS	National Bureau of Statistics – Tanzania
NEPA	National Environmental Policy Act
NUANCES	Nutrient use in animal and cropping systems-efficiencies and scales framework
OECD	Organisation for Economic Co-operation and Development
PIA	Poverty Impact Assessment
PIPA	Participatory impact pathway analysis
ReACCT	Resilient Agro-landscapes to Climate Change in Tanzania
RISE	Response-inducing sustainability evaluation
ScalA	Scaling up of Good Agricultural Practices

Stdev.	Standard deviation
TOA-MD	Trade-off Analysis Model for Multi-Dimensional Impact Assessment
Trans-SEC	Innovating Strategies to safeguard Food Security using Technology and Knowledge Transfer
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UPS	Upgrading strategies (activities / measures among the food value chain components, which improve the food security on village level)
URT	United Republic of Tanzania
USAID	United States Agency for International Development
WFP	World Food Programme
WOCAT	World Overview of Conservation Approaches and Technologies
ZALF	Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e.V.(Leibniz-Centre for Agricultural Landscape Research (ZALF) e.V.)
WSSD	World Summit on Sustainable Development

1 General introduction

"Would you tell me, please, which way I ought to go from here?"

"That depends a good deal on where you want to get to," said the Cat.

"I don't much care where" said Alice.

"Then it doesn't matter which way you go," said the Cat.

"So long as I get somewhere," Alice added as an explanation.

"Oh, you're sure to do that," said the Cat, "if you only walk long enough."

Picture 1: Lewis Carroll, Alice in Wonderland

In the real world, we cannot simply "walk" long distances without orientation to get "somewhere", particularly when we consider critical subjects such as food security. We need to plan effectively and take decisions for suitable and sustainable solutions. Ex-ante impact assessment is a valuable and useful approach/tool to support the achievement of this goal. Ex-ante impact assessment is defined as "the process of identifying the future consequences of a current or proposed action"(IAIA 2009). Impact assessment has a dual nature: it is a technical tool for analysing the consequences of planned intervention (policy, plan, programme and project) providing information to stakeholders and decision-makers and it is a legal and institutional procedure linked to the decision-making process of a planned intervention (IAIA 2009). To enhance food security in rural regions in developing countries, we must not lose time and we need to decide and provide solutions that improve the situation now and in the future.

1.1 Sustainable agricultural development to improve food security

The majority of the 780 million undernourished people in 2014 to 2016 live in developing regions. Food security remains a major challenge in Africa, particularly in Sub-Saharan Africa, where 23.2% of the population is undernourished, altogether amounting to approximately 220 million people, which is the highest prevalence in the world (FAO 2013, 2015). The definition of food security agreed upon at the 1996 World Food Summit states that food security “exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life’’ (FAO 1996, 2009). Food security has four dimensions: availability, access, utilisation and stability (WFP 2013; FAO 2013), which the WFP (2013) defines the dimensions as follows: 1) availability: “the presence of food through all forms of domestic production, commercial imports and food aid”; 2) access: “the households ability to acquire adequate amounts of food”; 3) utilisation “the ability of members of a household to make use of the food to which they have access”; and 4) stability: “the ability to avoid inadequate access because of weather conditions, social, economic or political instability”.

Agricultural development - particularly of small-scale farming - is the backbone of food security and poverty alleviation, especially in developing countries (WSSD 2002; FAO 2013). More than 90% of farms worldwide are managed by individuals or families (IAASTD 2009; IFAD and UNEP 2013). 84% of these farms are smaller than two hectares. Indeed, even though these farms produce more than 80% of the world’s food in terms of value and supply local and national markets, most small family farmers are poor and food-insecure (IAASTD 2009; Dethier and Effenberger 2012; IFAD and UNEP 2013; FAO 2015).

Agriculture faces multiple challenges, requiring the development of agricultural solutions with a high environmental, economic and social performance (Deytieux et al. 2016). Furthermore, agricultural development demands a sustainable approach for a long-lasting improvement of the food situation (WSSD 2002; FAO 2013). Sustainable agriculture is socially just, ecologically sound, economically viable and it aims to produce the food needed to achieve food security (IAASTD 2009; Cavatassi 2010; FAO 2013). According to Jayne et al. (2010), “without renewed attention to sustained agricultural productivity growth, most small farms in Africa will become increasingly unviable economic and social units”. Jayne et al. (2010) list the major challenges for smallholders in Sub-Saharan Africa, namely the unequal distribution of land and particularly the small land size per capita of smallholders, the low productivity of small farms due to a lack of access to inputs, the high labour migration of rural population to the urban areas due to a lack of income-generating activities, a lack of linkage of small farmers to the markets, a lack of literacy and non-farm income and farm policies of high-income countries. In order to respond to the current and future challenges and societal needs, various actions have to be taken in agriculture to evolve towards more sustainable farming practices. Coteur et al. (2016) state that: "These actions imply strategic choices and suppose adequate sustainability assessments to identify, measure, evaluate and communicate sustainable development. However, literature is scarce on the link between strategic decision making and sustainability assessment". Sustainability impact assessment can be seen as "a range of processes that all have the broad aim to integrate sustainability concepts into decision making" (Pope, 2006) or "a process by which the implications of an initiative on sustainability are evaluated" (Pope et al., 2004).

1.2 Ex-ante sustainability impact assessment and agricultural development in the development context

In practice there is often more focus on ex-post rather than ex-ante impact assessment at the project and programme level (Silvestrini 2011). Nevertheless, development initiatives focus on enhancing the agricultural production of smallholder farmers in developing countries. Because smallholder livelihoods are fragile, the impact of development initiatives needs to be assessed prior to implementation, with the primary goal of increasing the probability that these initiatives will improve the livelihoods of impoverished people in the respective project regions, as well as avoiding negative impacts (EIARD 2003; Schindler et al. 2016c). Ex-ante impact assessment is a process that identifies the future consequences of an intended action (IAIA 2009) and consequently is part of the planning process of intended interventions. There is a strong emphasis on the suitability and sustainability of planned projects and programmes, whereby assessing this requires appropriate methods. The theory and practice of ex-ante impact assessment are expanding. There is a large number of methods related to different types, including environmental, social and economic. The new approach to ex-ante impact assessment is sustainability impact assessment, which places emphasis on delivering positive net sustainability gains now and in the future (Bond et al. 2012). At present, we observe a wide diversity of practices and methodology in the field of sustainability impact assessment (Sadok et al. 2008; Pope et al. 2013; de Olde et al. 2016). Pope et al. (2013) highlight that "[…] the lack of a consistent and agreed methodology is perceived as a strength allowing for flexibility and context-specific approaches". The number of methods and tools available is still continuously increasing (Sadok et al. 2008). Schindler et al. (2015) compared a variety of methodological approaches that claim to be sustainability impact assessments and are applied in agricultural development projects (see Annexe 1 for full paper). They range from quantitative modelling approaches over indicator/interview-based approaches to more participative frameworks. The methodological approaches vary regarding their initial point of observation and they are applied in various thematic agricultural sectors, focusing - for example - on poverty reduction, the sustainability of land-use policies or scaling-up potential of sustainable crop production. The majority of approaches make use of a method mix - i.e. of qualitative as well as of quantitative analysis practices - while others only use qualitative data and several modelling approaches work only quantitatively. The level of application and spatial scale of impact interpretation strongly varies between the approaches (Schindler et al. 2015). The time needed for the application of the methodological procedures varies from several days to a few months, depending on the scale of the analysis. Moreover, the end user of the results varies. Some methods foresee that the results of the analysis are discussed with the farmers and decision-makers, who form the actual target group for finding solutions in a participative way. By contrast, others use the results for internal decisions concerning whether projects will be implemented or how they will have to be modified to reach the targeted sustainability. The time horizons used to project impacts into the future vary from method to method from short-term impacts of one season to longer-term impacts of 5-10 years (Schindler et al. 2015). Only few existing methodological approaches follow the holistic understanding of sustainability impact assessment, because only those approaches that a) equally integrate all three sustainability dimensions (economy, environment and social dimension), b) respect their interrelations, c) involve stakeholders actively at every step of the assessment process and d) focus on exchange and learning can be considered as a complete or holistic approach of sustainability impact assessment (Pope et al. 2004; Ness et al. 2007; Hacking and Guthrie 2008; Bond and Morrison-Saunders 2011; Bond et al. 2012; Singh et al. 2012). Given that sustainability impact assessment is context-related, it is important to clearly define sustainability regarding a certain subject in a geographical context (Bond et al. 2013).

The active involvement of local stakeholders - particularly farmers - is crucial in ex-ante impact assessment for sustainable farming (Bond and Morrison-Saunders 2013; Bond et al. 2012). Different authors argue that their direct involvement is very effective for strategic decision-making purposes, providing an acceptance of the outcomes because the results will include their own viewpoints and different knowledge sources are brought together (Lang et al. 2012). Webler et al. (1995) argue that public participation in sustainability impact assessment is valuable: “The competence of the final decision is higher when local knowledge is included and when expert knowledge is publicly examined” and “the legitimacy of the final outcome is higher when potentially affected parties can state their own case before their peers and have equal chance to influence the outcomes”. Furthermore, other authors underline that the participatory process in sustainability impact assessment will increase social learning, awareness of their responsibility in the sustainable development of their agricultural sector and ownership of decisions taken (Coteur et al. 2016; Triste et al. 2014; Reed et al. 2010). Bond et al. (2013) argue that sustainability assessment has the potential to considerably increase the sustainability performance of planning outcomes and decision-making. Therefore, it should be an integrated step of development initiative planning (Sadok et al. 2008; Stoeglehner and Neugebauer 2013; Schindler et al. 2015). Nevertheless, even though the theoretical discourse is quiet advanced, both implementing institutions and scientific discourse still have an extensive backlog demand regarding the practice of ex-ante impact assessment for sustainable development (Silvestrini 2011).

1.3 Research question and hypothesis

Within the framework of this dissertation an impact assessment methodological approach was developed, which follows the theoretical principles of sustainability impact assessment. Following a review of existing frameworks, it was decided to use the Framework for Participatory Impact Assessment (FoPIA) and to adapt it for impact assessment at the farmer level (Schindler et al. 2015). The adapted FoPIA was applied with farmers to four case study sites in rural Tanzania: in Ilolo and Idifu in Dodoma Region and Ilakala and Changarawe in Morogoro Region. The outcomes of this ex-ante impact assessment at the farmer level were analysed and further compared with the impact assessment results of an international researcher consortium.

The thesis aims to answer the following major **research question**:

Does sustainability impact assessment with farmers have an added value in agricultural intervention planning for improved food security?

This research follows the **hypothesis** that:

Sustainability impact assessment with smallholders supports project planning and developing solutions for sustainable and locally adapted agricultural development.

1.4 Food security in Tanzania

Food security is among the most pressing challenges facing humankind. Fluctuating market situations, droughts as well as related plant diseases are increasing and enhancing the unpredictability and insecurity of regional food supply, especially in Africa (Foley et al. 2011; Ziervogel and Ericksen 2010). The United Republic of Tanzania ranked 151nd out of 188 countries in the recent UN Human Development Index (UNDP 2015) and 77th out of 104 on the 2015 Global Hunger Index (IFPRI 2015). The proportion of undernourished people lies at 32.1% and the prevalence of stunting in children under five years is 34.7% (IFPRI 2015). Food security remains a major challenge for this country. Poverty and malnutrition remain prominent features of Tanzania's human development picture. Tanzania's current food security situation is characterised by seasonal and regional food shortages. Despite significant economic and agricultural growth in Tanzania over the past decade, along with improvements in health, education and other infrastructure, the rates of household poverty and food shortage have not been substantially reduced. Access to food and the ability to acquire food remains a major challenge. As an example, from 2000 to 2007, the share of the population living below the food poverty line - which represents the average cost of obtaining sufficient food to meet per person calorie needs in the poorest 50% of households - only very marginally decreased, from 19% in 2000/2001 to 17% in 2007 (WFP 2013). In several councils of Tanzania we find an unacceptable malnutrition status of children under five years old. Many households are expected to experience food and nutrition security conditions with very low resilience (Tanzania, U.R. 2012). Agriculture is central in the battle against hunger, although the poor performance of the sector - particularly in food production - is the main hurdle. There is an urgent and continuous need for suitable and sustainable food system enhancement (Chemonics International Inc. 2010; Hawkes and Ruel 2011; Tanzania, U.R. 2011; Tanzania, U.R. 2012).

1.5 Study area description[1]

According to the National Household Budget Survey (2007), most Tanzanians depend on agriculture for their livelihoods. The sale of food crops provides the main source of income for 40% of households. At the same time, rural households in Tanzania spend approximately 66% of their income on food. The majority of poor people live in rural Tanzania, with approximately 83% of individuals living below the basic needs poverty line, defined as the costs of meeting the minimum adult calorific requirement with a food consumption pattern typical of the poorest 50% of the Tanzanian population, inflated by the non-food share of expenditure of the poorest 25% (NBS 2011). Simultaneously, the smallholder agricultural sector provides 95% of the national food requirements.

In this study, we collected data from four villages located in two different climatic regions of Tanzania, namely semi-arid Dodoma and semi-humid Morogoro (Figure 1). The two regions represent the majority of farming systems in Tanzania (USAID 2008). The Dodoma Region is particularly sensitive to food insecurity, whereas Morogoro has both food-insecure and food-secure areas. Morogoro is better-off compared with Dodoma in terms of education. In Morogoro, 18% of men and 24% of women have never had access to education, whereas in Dodoma 33% of males and 40% of females have no education (URT 2011). Dodoma has the highest rate of stunted under-fives (approximately 80%) among all regions in Tanzania. The level of child stunting in Morogoro is of approximately 60% (URT 2011). Both regions have a low population density, with fewer than 50 people per square kilometre. The average household size in Morogoro is 4.3 people and in Dodoma it is 4.6 persons per family (NBS 2014). Dodoma is characterised by a higher level of outmigration compared with Morogoro (URT 2006).

The villages of Ilakala and Changarawe are located in the semi-humid (600-800 mm) Morogoro Region. The Morogoro Region is characterised by flat plains, highlands and dry alluvial valleys with

[1] A detailed case study description can be found in Schindler et al. (2016b) – 1st paper of this dissertation

mainly loamy soils. Short-term rains start in October and last until December, while long-term rainfall starts in February and continues into May. Agriculture is the main economic activity and most people engage in farming of both subsistence and cash crops, partly with livestock. The cropping systems are primarily based upon maize, sorghum, legumes, rice and horticulture. Sesame and sunflower are major cash crops grown by smallholder farmers. Farmers mainly use animal power for tillage, although tractors are also used by a very few farmers. There is a lack of transformation and value-adding infrastructure, such as oil milling machines. The village of Changarawe has relatively good market access and is relatively better-off in terms of food availability, whereas Ilakala has relatively poor market access and exceedingly severe problems of food security.

The other two case study site villages - Ilolo and Idifu - are situated in the semi-arid Dodoma Region, located on the central plateau of Tanzania. The landscape is characterised by flat plains and only small hills. Rainfall (350-500 mm) is unreliable. The soils are mainly reddish-brown loamy sands. The food system is primarily based upon sorghum and millet, with a long history of livestock husbandry (Mnenwa and Maliti 2010). Crop production and livestock - particularly cattle - constitute the mainstay of the economy in terms of providing income, employment and ensuring adequate food supplies. The farmers also grow sunflower and sesame as cash crops. Farmers mainly use animal power for tillage and hand hoes for field preparation. Ilolo is relatively better positioned in terms of market access compared to Idifu.

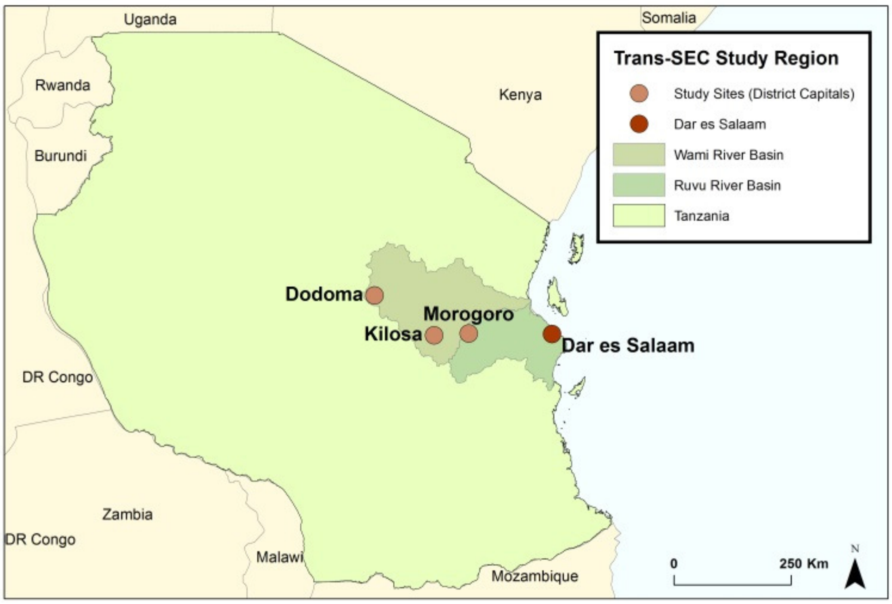

Figure 1: Map of Tanzania with indicated project areas (Source: Schaefer and Dietrich (2015))

2 Theoretical background

2.1 History of impact assessment

Since 1995, six core practice areas of impact assessment have emerged: environmental impact assessment, strategic environmental assessment, policy assessment, social impact assessment, health impact assessment and sustainability assessment (Bond and Pope 2012).

2.1.1 Environmental impact assessment

The first type of impact assessment was environmental impact assessment. The first formal assessment system for environmental impacts was developed within the framework of the US National Environmental Policy Act in 1970. This legislation act was implemented as a political response to the changing scale and nature of industrial development after World War II, with growing public dissatisfaction about the environmental consequences of economic development and the failure of existing decision tools (Cashmore 2004). Environmental impact assessment is nowadays widely applied: 191 countries either have national legislation or have signed some form of international legal instrument that refers to the use of environmental impact assessment to identify and evaluate environmental consequences of planned development actions, whereby it is firmly embedded in domestic and international law (Morgan 2012). Environmental impact assessment is majorly applied for project-level assessments (Morgan 2012) and it is a well-recognised instrument in environmental management being applied for decision-making in several contexts, including international development and trade policy (Cashmore et al. 2009).

A number of specific forms of impact assessment have been developed since the 1970s, mainly induced by dissatisfaction with the environmental impact assessment practised during that time. Shortcomings were mentioned, such as its strong biophysical focus and neglect of social issues (Morgan 2012). Environmental impact assessment is primarily concerned with how a proposed development should take place to minimise negative environmental - particularly biophysical - impacts.

2.1.2 Strategic environmental assessment

Strategic environmental assessment is applied to identify and evaluate the potential impacts of policies, plans and programmes (Fundingsland Tetlow and Hanusch 2012). It was developed in the 1990s and is rooted in environmental impact assessment. Strategic environmental assessment focuses on the choices of alternative developments during the earlier stages of decision-making whereby environmental and sustainability considerations are taken into account during the early stages of decision-making (Fundingsland Tetlow and Hanusch 2012). Strategic environmental assessment respects the issue that an institutional planning framework and the programmes and plans in question are influenced by environmental, social, economic, cultural and political aspects.

Strategic environmental assessment gives the decision-maker a holistic understanding of environmental and social implications of a proposed policy to move policy towards sustainable outcomes (Brown and Therivel 2000).

2.1.3 Policy assessment

Furthermore, policy assessment aims to inform decision-makers about the possible impacts of proposed policies before they are agreed and implemented, whereby it is purely "ex-ante" (Adelle and Weiland 2012). Policy assessment evolved due to the criticism of strategic environmental assessment focusing too much on a project and programme appraisal and not starting sufficiently early in the policy cycle (Owens et al. 2004). Some OECD countries started using policy assessment in the 1990s: by 2008, all 31 OECD countries applied it or were in the process of adopting it (Adelle and Weiland 2012). Many policy assessment systems focusing on assessing the economic and administrative impacts of policies were later revised to consider a wider range of impacts. The EU uses one of the most advanced policy assessment approaches, integrating social, environmental and economic impacts. There is enormous variation in terms of how to conduct policy assessment (de Ridder et al. 2007; Adelle and Weiland 2012).

2.1.4 Social impact assessment

Social impact assessment focuses on social impacts and social issues caused by interventions. It has been applied since the 1970s along with environmental impact assessment and as a requirement set by the National Environmental Policy Act (NEPA) of the USA. Communities are involved in a participatory process to identify impacts, holding discussions on desired futures and having negotiations and agreements on the possible impacts and benefits. Social impact assessment helps to gain a better insight into the community's interests, needs and concerns (Esteves et al. 2012). It goes beyond preventing or mitigating of negative impacts and also includes issues such as building social capital, knowledge capacity building, good governance, community engagement and social inclusion (Vanclay 2006). Practitioners work with concerned communities to achieve better outcomes for them. Social impact assessment is internationally practised in advance of project interventions and thus is included as part of the environmental impact assessment. Social impact assessment is not only used ex-ante, but also as an ongoing process of management and implementation to proactively respond to impacts during implementation. Social impact assessment experts consider this type of assessment as an interdisciplinary and/or transdisciplinary social science, integrating "[…] social science that incorporates many fields including sociology, anthropology, demography, development studies, gender studies, social and cultural geography, economics, political science and human rights, community and environmental psychology, social research methods and environmental law, among others" (Esteves et al. 2012).

2.1.5 Health impact assessment

Health impact assessment has matured over the past two decades, aiming to protect and promote public health. Unlike other impact assessments, health impact assessments evolution is not rooted solely in environmental impact assessment, but is mainly derived mainly from the "[…] public health professional movements that have emphasized its potential role in promoting action for health at a policy level and as a measure for redressing and promoting more equitable health impacts (Harris-Roxas et al. 2012)". At present, most voluntary health impact assessments are undertaken by the public sector, although the private sector is also increasingly adopting health impact assessment, stimulated by industry best practice standards and internal organisational standards. Harris-Roxas et al. (2012) emphasise the need for an international consensus on procedures, governing values and standards that apply to health impact assessment use.

2.1.6 Sustainability impact assessment

One of the most recent approaches is sustainability impact assessment, which was also used in this thesis. It supports decision-making and strategic planning towards sustainable development in a given context (Tscherning et al. 2008; OECD 2010). Sustainability impact assessment is the only type of impact assessment that considers and integrates the three pillars of sustainable development equally (Pope et al. 2004; Bond et al. 2012; OECD 2010). It is primarily defined as a process that steers decision-making and strategic planning towards sustainability, as well as ensuring net sustainability gains in the present and future (Ness et al. 2007; Hacking and Guthrie 2008; Bond and Morrison-Saunders 2011; Bond et al. 2012; Singh et al. 2012; OECD 2010). Sustainability impact assessment not only considers environmental, social and economic implications, but also analyses the interrelations between the three pillars (Pope et al. 2004). It is becoming common as a decision-making procedure with the goal of anticipating the sustainability of policies, plans, projects, programmes or activities prior to implementation (Pope et al. 2004; Hacking and Guthrie 2008; Bond and Morrison-Saunders 2011; Bond et al. 2012). Gibson (2013) and Bond et al. (2012) outline some imperative criteria of sustainability impact assessment: the development initiative must have a positive contribution to a sustainable future, all key factors that affect a sustainable future as well as their interlinkages are considered, the interdependence of ecology, economy and society is respected, induced trade-offs between different sustainability dimensions are highlighted and they are discussed in an open, participative and accountable manner with the aim of being minimised, the local context is respected, effective criteria regarding the people and context concerned are used, participation at all levels from government to society is emphasised, and it engenders learning throughout. The diversity of methodological approaches is seen as a strength that acknowledges pluralism (Bond et al. 2012).

2.2 Impact assessment theory

Several impact assessment types and many impact assessment studies have been published. Kørnøv (2015) reviewed over 500 impact assessment studies published between 1999 and 2014 drawing the overall conclusion that the majority of impact assessments contain empirical research that is relatively disconnected or fails to mention the theory to which it is related. There is strong potential for advancing the use of theory in impact assessment research. Gaining a deeper insight into the impact assessment theory applied would help researchers to better grasp the complexity involved in impact assessment practice. Kørnøv (2015) emphasises the need for a more coherent theory building in impact assessment to strengthen our understanding of barriers and facilitators to effectiveness and inform the design of interventions to improve impact assessment in practice. The need for a more coherent theory building and evolving the impact assessment research agenda has also been raised by several authors (Cashmore 2004; Wallington et al. 2007; Pope et al. 2013). Pope et al. (2013) argue that although the fundamentals of impact assessment have their roots in environmental impact assessment, "[…] each branch of the field is distinct in also drawing on other theoretical and conceptual bases that in turn shape the prevailing discourse in each case, generating increasing degrees of specialization within each sub-field". Learning theory (Kørnøv 2015), planning theory (D. P. Lawrence 2000; Morgan 2012; Richardson 2005; Fundingsland Tetlow and Hanusch 2012), policy theory (Kornov and Thissen 2000), decision theory (Kornov and Thissen 2000) and theories of power (Cashmore et al. 2010; Hansen et al. 2013) are mentioned as relevant theories that impact assessment builds upon.
In the following, "planning theory" and "social learning theory" are presented in further detail. Insights into the link between these two theories and sustainability impact assessments are given. The contemporary planning theory: "communicative planning" as well as recent developments in the field of "social learning theory" characterise the methodological sustainability impact assessment approach as applied in this study.

2.2.1 Social learning theory

The social learning theory was developed by Bandura (1971, 1977). He studied how individuals' behaviour depends on social interaction. He claims that people learn through observing others' behaviours, actions and reactions, as well as their outcomes. Hence, he focused on individual learning and argued that it takes place in a certain social environment, influenced by norms and role models. His theory building followed a purely psychological approach. Habermas (1984) developed a more sociological approach, describing social change as a process of social learning. He argues that learning may occur during a "[…] genuine exchange of ideas and arguments during which ideas and perceptions change through persuasion" (Reed et al. 2010).

Furthermore, Lave and Wenger (1991) describe social interaction as an important component of learning, whereby learners not only internalise knowledge at the individual level but also become involved in a community of practice. Hence, learning is situated and embedded within activity, context and culture and it occurs during the process of co-participation rather than in the heads of individuals. It is “recognized as a social phenomenon constituted in the experienced, lived-in world. Wenger (2000) highlights that learning “[…] is an interplay between social competence and personal experience. It is a dynamic, two way relationship between people and the social learning systems in which they participate”.

Today, social learning is discussed in the context of public involvement, as an interactive approach towards decision-making and problem-solving and a process of collective and communicative learning that is thought to lead to a shared understanding of the situation, leading to mutual agreement within the considered community (Figure 2).

Tippett et al. (2005) argue that only a learning approach that results in enhancing a group’s ability to change its underlying dynamics and assumptions can be considered as social learning. Encouraging social learning implies an emphasis on the process of involving different stakeholders in developing solutions and making decisions, whereby it should not only be the experts who develop solutions. Theories of social learning are useful to build the design of collaborative processes (Muro and Jeffrey 2006). Pretty (1995) notes that there was a significant rise in participatory learning in the context of agriculture development during the 1980s and 1990s. Social learning has been highlighted to support participative planning (Pahl-Wostl 2002; Pahl-Wostl and Hare 2004) and impact assessment (Webler et al. 1995; Saarikoski 2000). Social learning is often cited in connection with sustainable development (Muro and Jeffrey 2006). Already in the late-1980s, Milbrath (1989) linked the term social learning to sustainable development, using the expression “self-educating community” to describe situations in which people learn from each other and nature.

Webler et al. (1995) described the components of social learning on both individual and community level by considering personal interests and common interests, coming together to reach agreement on collective action to solve a mutual problem.

Webler et al. (1995) describe criteria that serve as precondition for effective social learning. Besides *cognitive enhancement* and *moral development*, these also include criteria for *fairness* and *competence*. *Cognitive enhancement* is the acquisition of knowledge, including learning about the state of a problem, learning about solutions and consequences, learning about other peoples and the community’s interests and values, learning about one’s own personal interests, as well as learning about methods, tools and strategies to communicate and find solutions. On the other hand, *moral development* demands setting aside individual interests and acting for the good of the community, enhancing peoples capacity to judge what is right or wrong, including taking over responsibility for the community, being able to understand the other's perspective, developing skills for moral reasoning and problem-solving, developing a sense of solidarity, learning how to integrate new cognitive knowledge into the decision-making and learning how to cooperate with others in solving collective problems. The criteria for *fairness* and *competence* include the notion that everyone has a chance to participate in the process, supporting an atmosphere that encourages all participants to give their opinion, discuss openly and have an organised exchange with experts (Webler et al. 1995). Webler et al. (1995) complement the notion that social learning happens when the group transforms from a collection of individuals pursuing their private interests to a 'community' that defines a common purpose and is oriented towards shared interests.

Reed et al. (2010), Tippett et al. (2005) and Bull et al. (2008) also find evidence that participatory processes might facilitate social learning. However, they also emphasise that participation does not necessarily imply that social learning takes place, outlining that "social learning is not an automatic outcome of a participatory process".

Tippett et al. (2005) lists key factors supporting social learning, such as:

- The interaction of different people with different viewpoints
- Learning from and with people, given that everybody has a different perception and experience of a certain issue, whereby differences need to be distinguished and discussed
- Exploration of potential and existing conflicts and the underlying reasons
- Active involvement of the stakeholders, based upon the notion that everybody needs to have the space to contribute their opinion
- The possibility to participate, because the feeling of exclusion creates conflicts, meaning that the decision on who participates needs to be transparent
- Real participation in the outcomes and the solutions/decision
- Methodological approaches need to be context-specific, considering the environmental, institutional and socio-economic context
- Effective participation can only take place in an environment of trust, transparency, respect and openness
- Skills/competency in moderation and mediation of the process, devoting full attention to the cultural and institutional context, integrating everybody actively in the process and building trust, managing conflict and institutional rivalries and encouraging the development of mutually-beneficial solutions
- Provision of sufficient time, given that time pressure may make the participants feel that they are not involved in decision making in a meaningful way

- Use of different types and communication tools, attempting to find different ways to represent technical information, making the process more accessible to a wide range of stakeholders, allowing participants to actively bring in their own knowledge

If these key factors are not respected, they are simultaneously potential barriers to social learning. Johnson and Wilson (2000) also mention a further barrier, namely that deeper power relations are subject to manipulation and dependency and are often not visible, whereby the less powerful in the community are often supressed. Therefore, a very sensitive moderator and a careful selection process of participants are critical to minimise this particular risk.
Learning is highly critical for sustainability impact assessment and according to Bond et al. (2012) it will occur through social learning. Sustainability impact assessment emphasises the implication of different level stakeholders (Gibson 2013; Bond et al. 2012; OECD 2010) in the assessment of solutions and in multi-level decision-making (Pope et al. 2004; Hacking and Guthrie 2008; Bond and Morrison-Saunders 2011; Bond et al. 2012). Webler et al. (1995) argued that participatory approaches in impact assessment supporting social learning processes need to aim to lead from uncoordinated individual actions to collective actions that reflect collective needs and understandings. Several authors argue that the social learning process in ex-ante impact assessment supports participative planning (Pahl-Wostl 2002; Pahl-Wostl and Hare 2004; Webler et al. 1995; Saarikoski 2000).

Figure 2: Model Social Learning (Source: adapted from Muro and Jeffrey (2006))

2.2.2 Planning theory

Ex-ante impact assessment is a part of planning and project/programme appraisal (Figure 3). It occurs prior to the start of an intervention (Maredia 2009; Schindler et al. 2016a). The use of systematic tools of impact assessment during planning dates from the 1950s with multilateral and bilateral donors. Development agencies began to use ex-ante impact assessment such as environmental impact assessment or social impact assessment to predict a project's likely consequences as a condition to approve, adjust or reject the project funding (Maredia 2009).
Given that ex-ante impact assessment is part of planning, the development of planning theory also indicates the tremendous development in impact assessment during the past 50 years (D. P. Lawrence 2000).

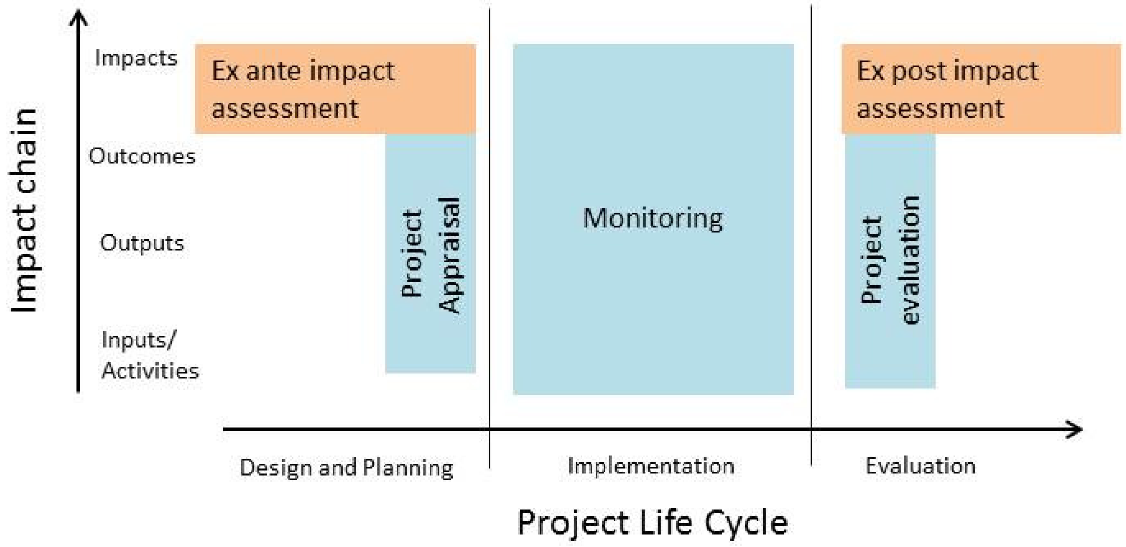

Figure 3: Impact assessment in a project life cycle (Source: adapted from Maredia (2009))

2.2.2.1 Rational planning

The early planning theory in the 1960s and 1970s was dominated by “rationalism”. According to the Oxford dictionary, rationalism is defined as “the practice or principle of basing opinions and actions on reason and knowledge rather than on religious belief or emotional response”. Rational planning theory describes an idealised comprehensive planning model, which predetermines development and is mainly dictated by technical experts and researchers. The planning process is logical, consistent and systematic. It follows a top-down approach and aims to develop a clear basis for decision-making (D. P. Lawrence 2000). The form of environmental impact assessment that emerged in the 1970s was clearly influenced by this planning model of rationalism (Morgan 2012). Fundingsland Tetlow and Hanusch (2012) emphasise that the beginnings of environmental impact assessment were initially dominated by the implicit assumption that a defined objective and simply quantifiable evidence on the environmental effects would lead to better decision-making. Quantitative techniques of data collection were emphasised (Bartlett and Kurian 1999). In fact, Duinker (1987) cited in Bartlett and Kurian (1999) even argued that in forecasting environmental impacts it is better to use quantitative and incorrect data than qualitative and unstable information that might be gathered in a qualitative participatory process. Already in the 1960s, rationalism attracted the criticism that researchers and technical experts dominated the process, the integration of the population or wider public is neglected and non-scientific knowledge is not considered, decision-making and dialogue are not part of rational planning, it fails to integrate the features of the context and the existing resource and cognitive limits, and it fails to develop possible alternative solutions by recognising the value-based nature of decision-making (Richardson 2005; D. P. Lawrence 2000). Rational planning is characterised as having a strong technical emphasis, whereby planners and technical professionals deliver information and define solutions as a basis of choice for the decision-makers (Morgan 2012). Based upon the criticism on rationalism, planning theory was further developed. During the 1980s and 1990s, alternative concepts in planning theory were identified and debated (Healey 1993) such as *communicative planning* theory.

2.2.2.2 Communicative planning theory

"Communicative planning" is one of the most recent planning theories. Sustainability impact assessment is strongly related to this theory and its core principles correspond with the basic values of this type of impact assessment. Communicative planning is a reaction to rational planning and strongly criticises if planning is only undertaken by a planner without recognising the context and different stakeholders in the planning process. Its outline began to emerge during the 1980s. The new planning direction of communicative planning characterises planning as an interactive process in a complex and unique context. The interaction of stakeholders creates a mutual understanding, is respectful, values and acknowledges the experience, understandings and knowledge of the different involved communities and aims at a mutual reconstruction of what constitutes the interests of the various participants (D. P. Lawrence 2000). The process has the potential to change, transforming material conditions and power relations through the continuous effort to create a common understanding among participants. This communicative process is the basis for the planner to build upon the information that everybody contributes (Healey 1993). It emphasises communications and interactions as a critical element of planning and focuses on consensus building via argumentation, discussion and negotiation (Healey 1993; D. P. Lawrence 2000). The promotion of communicative approaches to planning demands actively including stakeholders and communities in the process. Different stakeholders can bring in their experiences, stories and ideas. Planners are considered as facilitators of this communication process. The professional technocrats move from a controlling role to a facilitating role in the decision-making process (Wilkins 2003; Elling 2009). They need to have the mediation capacity to solve problems and lead towards consensus-building. D. P. Lawrence (2000) emphasises that communicative planning may contribute to transparent decision-making, creative problem-solving and a greater likelihood of public agreement, acceptance and support.

Sustainability impact assessment is strongly influenced by communicative planning theory. Here it is recognised that decision-making is influenced by a variety of different factors, including environmental, social, economic, cultural and political issues, while the context needs to be understood in the decision-making process (Fundingsland Tetlow and Hanusch 2012). Morgan (2012) and Richardson (2005) also emphasise the need for communicative planning and mutual understanding in impact assessment, while highlighting that potential conflicts and power relations are present throughout impact assessment. Impact assessment practitioners should be aware of and sensitive to the power relations found in decision-making processes that can hinder effective participation and exacerbate injustice.

2.3 Sustainability impact assessment: from disciplinary to transdisciplinary research

2.3.1 Disciplinary research

Disciplinary research provides scientists with frames of references, methodological approaches and topics of study, theoretical discourses and technologies. However, disciplinary research can hardly grasp the complexity and interlinkages of human, nature and biophysical systems. R. J. Lawrence and Després (2004) call disciplinary research a "[…] narrow vision of so-called experts who do not address fundamental issues but only topics isolated from their societal context." One single discipline cannot provide solutions for complex problem-solving. With the consciousness of these limitations of simple disciplinary research, the last decade has been characterised by the intention to integrate the knowledge and competency of different disciplines, "[…] thus breaking down the methodological, epistemological and ontological boundaries that prevent shared understanding of complex issues (Stock and Burton 2011)". Disciplinary research often fails particularly regarding sustainability issues, where economic, ecological and sociological challenges have to be approached simultaneously (Vandermeulen and Van Huylenbroeck 2008). The search for sustainable solutions inherently integrates different disciplines and forces research to bridge the natural and social sciences (Jerneck et al. 2011; Luks and Siebenhüner 2007). In the following the different levels of integrative research are presented:

2.3.2 Multidisciplinary research

In multidisciplinary research, different disciplines are represented. In literature, it is described as the least integrative from the integrated research (Stock and Burton 2011). Researchers come together sharing knowledge and comparing results from their disciplinary studies in a particular context. Each discipline works in a self-contained manner and a problem is approached from the different angles of different disciplines (R. J. Lawrence and Després 2004). Nonetheless, there is no crosscutting interlinkage to generate new integrative knowledge (Tress et al. 2005). Stock and Burton (2011) argue that there is a "[…] lack of iterative research, a failure to cross disciplinary boundaries, the lack of integration in the research process, and a failure to engage non-academic stakeholders as participants in the research".

2.3.3 Interdisciplinary research

Interdisciplinary is already more integrative than multidisciplinary research. It is problem-oriented, focuses on complex problems and forces the involved researchers from the different disciplines to leave their "box" and try to create new knowledge (Stock and Burton 2011). There is a strong attempt to bridge the different disciplinary positions (Petts et al. 2008) and integrate natural and social scientists' knowledge as standard practice and provide a systematic outcome (R. J. Lawrence and Després 2004). Nevertheless, this approach also focuses also on scientific solutions without integrating different stakeholders and non-scientists.

2.3.4 Transdisciplinary research

Transdisciplinary is the most integrative research approach. It aims to develop a holistic approach towards problem-solving, involving different stakeholders and scientists in a joint project. The objective is to integrate and synthesise knowledge in such a way to address very complex real-world problems (Stock and Burton 2011). R. J. Lawrence and Després (2004) describe it as an approach focusing on the organisation of knowledge around complex issues and problems rather than the disciplines and subjects into which knowledge is commonly organised. Transdisciplinary research not only integrates academic research knowledge but also actively involves non-academic participants - such as farmers in agricultural research - in a participatory manner. Mobjörk (2010) distinguishes between “participatory transdisciplinary” and “consulting transdisciplinary”. “Consulting” here means that local stakeholders are involved by responding scientists’ questions, although they are not actively incorporated in the knowledge production process, while “participatory” transdisciplinary integrates the knowledge of non-scientists and researchers and triggers a mutual learning process. It requires that the participating researchers “overcome one’s disciplinary chauvinism” and open up their mind, being willing and open not only to other disciplines but also to alternative ways of thinking (Kumar Giri 2002) and creating joint understanding. Wiek (2007) emphasises that mutual learning is a prerequisite of transdisciplinary research. “For collaborative research, not only information must be exchanged but knowledge must also be generated in a cooperative manner”. Transdisciplinary research tries to understand and take into account the local contexts (Thompson Klein 2004). “One of its aims is to understand the actual world and to bridge the gap between knowledge derived from research and decision-making processes in society” (Ramadier 2004). We conclude that sustainability research - the context in which most of the work presented was undertaken - is inherently transdisciplinary research. The adapted FoPIA is a methodological approach that supports transdisciplinary research.

3 Project design and implementation

3.1 Research project

This study is integrated into the Trans-SEC "Innovating Strategies to safeguard Food Security using Technology and Knowledge Transfer: A people-centred Approach" research project, a five-year research project funded by the German Federal Ministry of Education and Research (BMBF), which started in May 2013. The project aims to identify successful agricultural upgrading strategies along local and regional food value chains to improve the food situation of smallholder farmers in four villages in Dodoma and Morogoro Regions, Tanzania. Those upgrading strategies are tested and adjusted via a participatory approach to be site-specific and sustainable. Potential upgrading strategies are disseminated for regional and national upscaling. The following procedural steps are followed in this project (Sieber and Graef 2013):

1. A stakeholder involvement process from the beginning, as an integral part of most analytical steps
2. Case study sites within the focal regions Morogoro and Dodoma are selected, set up and typologies of food value chains are developed
3. Upgrading strategies of good practice along the food value chains are screened and inventoried
4. An integrated in-depth analyses of food value chain components, their costs, benefits and impacts is carried out
5. A few of the most promising upgrading strategies regarding positive impacts and implementation are discussed and identified in a participative way for subsequent in-depth testing
6. An in-depth participative field testing and/or analysis of selected, most promising technologies are conducted for all food value chain components and requirements for their implementation are identified
7. The transferability and implementation capability are assessed for different scenarios and future condition simulations (model analysis)
8. A meta-model analysis including risk analysis and final climate proofing is used to identify hot spots of most sensitive, fragile regions and the potentials for alleviating food insecurity

This participatory ex-ante impact assessment approach with farmers applied during the final stage of the planning phase of agricultural upgrading strategies before their implementation was part of step 5 and is a component of work package 8 "Integration and dissemination", having the primary objective of acting as an integrating platform for the entire project and ensuring the effectiveness, positive impact and usability of the products developed among Trans-SEC partners and the stakeholders.

3.2 Framework for participatory impact assessment (FoPIA)

Sustainability is context-related. In particular, the active participation of farmers is crucial in the sustainability assessment for food security. Therefore, sustainability impact assessment should provide sufficient space and time with stakeholder groups to understand the local context and elaborate indicators that fully represent the analysed food system. A framework used under the label of "sustainability impact assessment" must have a positive contribution to a sustainable future. The interlinkages and interdependence of ecology, economy and society need to be respected, trade-offs analysed and minimised and embedded learning of the stakeholders encouraged. In this research a *transdisciplinary research approach* was applied. We integrated both researchers' and "non-academic" farmers' expert knowledge to identify positively and negatively assumed impacts that may result from the implementation of agricultural upgrading strategies. The sustainability impact assessment approach of agricultural upgrading strategies with the farmers is based upon the Framework for Participatory Impact Assessment (FoPIA) (Morris et al. 2011; König et al. 2010; König et al. 2012; König et al. 2013).

FoPIA was applied after methodological adaptations (Schindler et al. 2016b; Schindler et al. 2016c) during the last part of the planning phase prior to the implementation of agricultural upgrading strategies. The aim of the application of FoPIA was to systematically incorporate farmers' knowledge into the knowledge generation process and identify the positive and negative assumed impacts of proposed upgrading strategies to modify and adapt them - if necessary – prior to their implementation. Detailed information on the procedural steps of the adapted FoPIA is provided in the results sections: 4.1 Developing community-based food security criteria in rural Tanzania (Paper 1) and 4.2 Sustainability impact assessment to improve food security of smallholders in Tanzania (Paper 2). Nevertheless, in the following a brief introduction to FoPIA is provided.

As first described by Morris et al. (2011), the FoPIA was originally designed to complement quantitative computer-based sustainability impact assessment tools in the European context with a qualitative participatory approach (Helming et al. 2011) . At the same time, König et al. (2010) adapted FoPIA to be applicable in the context of developing countries (König et al. 2012; Purushothaman et al. 2012; König et al. 2013). The FoPIA provides a general assessment framework with a sequence of methods for conducting sustainability impact assessment in different regional contexts (Morris et al. 2011). However, it has mainly been applied to assess alternative land-use policies at the policy-maker level in different regional contexts (König et al. 2013). Within this thesis, FoPIA was further developed to be applicable at the community level to adapt food security strategies to the local conditions and needs. Within this thesis, the impact assessment is considered a component of the planning phase of programmes and projects. It helps to analyse the main challenges of interventions, providing the opportunity to select, adapt and modify measures (Silvestrini 2011; Schindler et al. 2016b).

The modified FoPIA comprises two main parts: 1) an analysis of the food security contexts and 2) ex-ante impact assessment of local food security upgrading strategies. The following methodological steps are a series of successive participatory stakeholder workshops.

Within part 1), the food security context is identified with the farmers. The farmers define their understanding of food security in their local environment. Subsequently, they discuss the different food security class levels in the village and define their characteristics. The farmers are asked about challenges that influence the local food situation, which are translated into food security criteria. The farmers individually score the importance of each criterion for their food security.

Within part 2) of the FoPIA, the upgrading strategies are presented to the farmers by researchers. In a following participatory analysis, the farmers elaborate the strengths and weaknesses of these agricultural upgrading strategies in small groups. Based upon these workshops, the farmers chose their preferred upgrading strategies for implementation in their village. An impact assessment follows, with the farmers ranking the assumed impacts of these particular upgrading strategies on each of the food security criteria. In a final presentation, all of the results are discussed with village elders and authorities. The stakeholders are asked for the feedback and add-on activities necessary for the successful implementation of these upgrading strategies. Finally, the plan of timing and distribution of responsibilities for the implementation of upgrading strategies are shared.

4 Results

4.1 1st Paper: Developing community-based food security criteria in rural Tanzania

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Developing community-based food security criteria in rural Tanzania

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Abstract Food security remains a major challenge in Sub-Saharan Africa. The widely acknowledged definition of food security and its four dimensions, availability, access, utilisation and stability, are somewhat abstract in the local context of small-scale farmers. Therefore, more site-specific information on the local food situation is needed to respond to the local food security challenges. Participatory elaboration of these criteria within the rural communities is crucial. The objective of this research was to elaborate community-based criteria in four selected study villages of Tanzania. We present an adapted methodological procedure based on the so-called Framework for Participatory Impact Assessment (FoPIA). Based on a series of farmer workshops, we analysed the local understanding of food security and derived a set of food security criteria. We found that these criteria cover the three dimensions of sustainability (social, economic and environmental), while simultaneously representing the four food security dimensions, showing that rural communities think holistically and consider multiple criteria and dimensions related to food security. Our participatory methodological approach was suitable for identifying the specific development priorities that need to be addressed for improved food security in a particular locality. The locally specific food security criteria can be used for impact assessment, monitoring and evaluation and, finally, for the adaptation of development measures to local contexts.

Keywords food security; food security criteria; food security indicators; participatory impact assessment; sustainable development

1 Introduction

An estimated 12% of the global population is currently unable to meet their dietary needs (FAO 2013). The majority of these people live in developing regions. Food security remains a major challenge in Africa, particularly in Sub-Saharan Africa, where the highest prevalence of undernourishment occurs (FAO 2013). The definition of food security agreed upon at the 1996 World Food Summit states that food security "exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life'' (FAO 1996, 2009). Food security has four dimensions: availability, access, utilisation and stability (WFP 2013; FAO 2013). The WFP (2013) defines the dimensions as follows: 1) Availability: "the presence of food through all forms of domestic production, commercial imports and food aid"; 2) Access: "the household's ability to acquire adequate amounts of food"; 3) Utilisation "the ability of members of a household to make use of the food to which they have access"; and 4) Stability: the ability to avoid inadequate access because of weather conditions, social, economic or political instability, etc. Hence, food security is a complex condition. To better understand particular food security challenges in a given environment, it is helpful to derive a set of criteria (FAO 2013).

The international community currently lacks consensus about the criteria that are needed to properly evaluate food security at the household level (Carletto et al. 2013). Several authors argue that a fixed set of criteria would be inappropriate to describe unique and complex systems and that food security criteria must be locally specific and relevant (López-Ridaura et al. 2005; Agol et al. 2014; Bell and Morse 2008; Cosyns et al. 2013). Although this context relatedness is accepted in theoretic discourses, in practice it often remains the researchers or the project managers who decide on criteria that describe the complex system of food security without actively involving the community. This set of criteria does not necessarily reflect what is really important in a community to improve the food security situation, and the corresponding analysis is often incomplete (Dale et al. 2013; Agol et al. 2014; Catley et al. 2007; Meadows 1998). Therefore, involving stakeholders is a prerequisite to arriving at meaningful criteria to understand local food security challenges (López-Ridaura et al. 2005; Morris et al. 2011; König et al. 2012). Even with participative approaches there is little involvement of those who are greatly concerned by food insecurity, the farmers themselves. It is the community, those who are at risk, that must identify the relevant criteria because communities have their own priorities for improving their livelihoods and they are experts in their local environment (Catley et al. 2007; Schindler et al. 2015). Little effort has been directed towards the development of methodological approaches to support the selection of site-specific criteria (López-Ridaura et al. 2005) in the agricultural development context, and simple, applicable field approaches that actively involve local farmers are lacking in particular. Such participatory approaches have higher potential for enhancing sustainable agriculture and food security (Chambers 1995; Neef and Neubert 2011). Only context-related criteria can be useful for systematic impact assessment, monitoring and evaluation of development measures to improve food security (Agol et al. 2014; Catley et al. 2007).

In this paper, we present a set of community-based food security criteria that were elaborated by applying a participatory methodological approach in four different case study villages in rural Tanzania. Our objective was to derive criteria, which could further be used for impact assessment, monitoring and evaluation of development measures, which aim at improving food security. We adapted the first part of the Framework for Participatory Impact Assessment (FoPIA) (Morris et al. 2011; König et al. 2012; König et al. 2013) to be applicable at farmers' level, with the objective of better understanding what the relevant food security criteria are at a local level, which are defined by those who are threatened most by food insecurity, the rural smallholder farmers (WFP 2013). In this study, a food security criterion is considered to be a standard relevant to the local food security situation at the case study sites. We analysed different perceptions of food security criteria across four case study sites and discussed their relevance to the local food system. We also assigned the criteria given by farmers to the three sustainability and the four food security dimensions to identify certain priority dimensions of local perception.

2 Materials and Methods

2.1 Study area

According to the National Household Budget Survey (2007), most Tanzanians depend on agriculture for their livelihoods. The sale of food crops provides the main source of income for 40% of households. At the same time, rural households in Tanzania spend approximately 66% of their income on food. The majority of poor people live in rural Tanzania, with approximately 83% of individuals living below the basic needs poverty line, which is defined as the costs of meeting the minimum adult calorific requirement with a food consumption pattern typical of the poorest 50 % of the Tanzanian population, inflated by the non-food share of expenditure of the poorest 25 % (NBS 2011). Simultaneously, the smallholder agricultural sector provides 95% of the national food requirements. In this study, we collected data from four villages located in two different climatic regions: Dodoma and Morogoro of Tanzania. The two regions represent the majority of farming systems in Tanzania (USAID 2008). The Dodoma Region is particularly sensitive to food insecurity, whereas Morogoro has both food-insecure and food-secure areas. Morogoro is better off compared with Dodoma in terms of education. In Morogoro, 18% of men and 24% of women have never had access to education, whereas in Dodoma 33% of males and 40% of females have no education (URT 2011). Dodoma has the highest rate of stunted under-fives (approximately 80%) among regions in Tanzania. The level of child stunting in Morogoro is slightly above the national average of approximately 60% (URT 2011). Both regions have a low population density, with fewer than 50 people per square kilometre. The average household size in Morogoro is 4.3 people and in Dodoma 4.6 people per family (NBS 2014). Dodoma is characterised by a higher level of outmigration compared with Morogoro (URT 2006).

The villages Ilakala and Changarawe are located in the semi-humid (600-800 mm) Morogoro Region. The Morogoro Region is characterised by flat plains, highlands and dry alluvial valleys with mainly loamy soils. The long-term rainfall starts in February and continues into May. The short-term rainy season lasts from October until December with much lighter and unreliable rainfalls compared to the long-term rainy season. Agriculture is the main economic activity, and most people engage in farming of both subsistence and cash crops, partly with livestock. The cropping systems are primarily based on maize, sorghum, legumes, rice and horticulture. Sesame and sunflower are major cash crops that are grown by smallholder farmers. Farmers use mainly animal power for tillage, but tractors are also used by very few farmers. There is a lack of transformation and value-adding infrastructure, such as oil milling machines. The village Changarawe has relatively good market access and is relatively better off in terms of food availability, whereas Ilakala has relatively poor market access and has exceedingly severe problems of food security.

The other two case study villages, Ilolo and Idifu, are situated in the semi-arid Dodoma Region, located on the central plateau of Tanzania. The landscape is characterised by flat plains and only small hills. Rainfall (350-500 mm) in this climate is unreliable. Soils are mainly reddish-brown loamy sands The food system is primarily based on sorghum and millet, with a long history of livestock husbandry (Mnenwa and Maliti 2010). Crop production and livestock, particularly cattle, constitute the mainstay of the economy in providing income, employment and ensuring adequate food supplies. The farmers also grow sunflower and sesame as cash crops. Farmers use mainly animal power for tillage and hand hoes for field preparation. Ilolo is relatively better positioned in terms of market access compared with Idifu.

2.2 Methodological approach

Adapting the existing FoPIA

In a preceding research phase, we compared different methods for impact assessment of farming interventions in the development context (Schindler et al. 2015). In this previous analysis, we also focused on criteria development, selecting FoPIA (Morris et al. 2011; König et al. 2012; König et al. 2013) as the most appropriate for our participatory approach. The participatory development of criteria is one step of the FoPIA logic. FoPIA has not yet been systematically applied at farmers' level or in the food security context. Therefore, we further adapted it to our needs. Originally, FoPIA was developed for land-use policy impact assessment among policymakers in Europe (Pérez-Soba et al. 2008; Helming and Pérez-Soba 2011). The framework was described in this regard by Morris et al. (2011). At the same time, the FoPIA framework was adapted by König et al. (2010) and further developed for application in the development context (König et al. 2012; Purushothaman et al. 2012; König et al. 2013). FoPIA provides a series of methods for conducting sustainability impact assessment by following three consecutive steps: 1) scenario development (case study selection, problem definition, scenario narratives of policy induced land management options); 2) specification of the sustainability context (analysis of land use functions, development of land use function assessment criteria); and 3) scenario impact assessment (impact assessment with and without trade-offs) (König et al. 2012).

In order to be applicable at farmers' level, we adapted the existing FoPIA approach. Our modified FoPIA consists of only two main steps: 1) analysis of the geographical and food security context and 2) impact assessment of local food security upgrading strategies.

In this study, we present the refinement of the first part of FoPIA, which addresses criteria development for application at the community level, particularly with smallholders, for the first time to elaborate food security criteria.

Operational data collection and criteria development

The data collection was embedded in the trans-disciplinary research project Trans-SEC: "Innovating strategies to safeguard food security using technology and knowledge transfer: A people-centred approach". This project focuses on the improvement of food security among small-scale farmers through the implementation of improved, so-called upgrading of strategies across entire food value chains. The food value chains cover the following components: production, processing, marketing and consumption.

The criteria were elaborated in three phases: 1) literature review, 2) a researcher workshop and 3) farmer focus group discussions. This three-phase process must be understood as an iterative process, starting from a general literature review of food security criteria. We then sharpened the focus on the local context during a workshop with Tanzanian scientists and experts who know the local environment well (phase 2). The criteria were elaborated and defined during the third phase, the farmers' focus group discussions, assuming that farmers know best about their food security challenges. Nevertheless, phases 1 and 2 were important in obtaining a deeper understanding on possible criteria regarding household food security.

Phase 1: Literature review

The literature review on food security criteria was mainly based on the following sources: the Declaration of the World Summit on Food Security (FAO 2009), EC and FAO (2008), FAO (2013), WFP (2014) and Crewett et al. (2011) and yielded a preliminary set of locally relevant criteria. We categorised the criteria according to three sustainability dimensions, environmental, social and economic (table 1).

Table 1 Food security criteria derived from literature review

Environmental	Social	Economic
Diversity in food crop production	Diversity and/ or quality of food intake	Quantity of HH food production
Soil quality (chemical, biological, hydrological or physical features)	Social and cultural acceptance, reducing social differences and conflicts	Access to food and other markets
	Access to education, training and social networks	Net-income and/or chance for additional off farm opportunities
		Resource use efficiency (labor, environmental, financial)
		Access to external inputs and infrastructure
		Implementation and maintenance costs

Sources FAO (2009), EC and FAO (2008), FAO (2013), WFP (2014) and Crewett et al. (2011)

Phase 2: Researchers workshop

This set of criteria was then discussed and revised during a workshop with approximately 20 Tanzanian and German agricultural scientists and experts. The criteria were modified or newly arranged or new ones were added, yielding the following final set (table 2):

Table 2 Food security criteria derived from workshop with scientists

Environmental	Social	Economic
Soil fertility	Diversity of food intake	Access to food and other markets
Quantity of household food production	Quantity of food available to household	Income
Diversity in food crop production	Appropriate technology/inputs used	Labour access
	Social and cultural relations	Labour availability (family labour)
	Gender balanced empowerment	Chance for additional off farm opportunities
	Access to education, training and social networks	

Phase 3: Farmers focus groups

The main focus of this exercise was to understand the farmers' perspective. The farmers' focus groups were conducted in April 2014. They were carried out without any content input from the scientists.

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There was a free brainstorming and discussion with the farmers because we wanted to capture their non-biased view on food security. No information from the preceding scientist workshop or literature review was presented. At each of the four case study sites, we carried out two focus group discussions with women and men held separately, yielding a total of eight focus group discussions. Preceding work in Trans-SEC indicated that women would only speak freely if men were not present in the same workshop session. Therefore, we first organised a women-only workshop, followed by a men-only workshop, each with 15 to 19 participants (table 3). We used the following criteria to guarantee a diversity of participants representing the village community: (I) representation of all sub-villages; (II) different age groups (young: age 15-25, adults, elderly people: age >= 60); (III) persons of different marital status (married, single, widow); (IV) a diversity of major occupations practised at the case study site (farming, pastoralism, activities other than farming); (V) economic status of the household (poor-moderate-better off); (VI) diversity of land ownership (rent, own, none); and (VII) mixture of participants who are household heads and who are not.

Table 3 Number of workshop participants per village

Region	Village	Workshop participants	No. of female participants	No. of male participants
Morogoro	Changarawe	30	15	15
	Ilakala	35	16	19
Dodoma	Idifu	35	19	16
	Ilolo	33	16	17

We followed five consecutive steps to elaborate the food security criteria (table 4). One moderator who spoke the local language, one translator and one researcher participated in each focus group discussion. The moderators guided the focus groups, and a simultaneous translation was provided by the translator to the researcher who observed the process. A female moderator conducted the female workshop, and a male moderator guided male farmers' workshops.

The following subjects were discussed with the farmers during the focus group discussions in order to gain an in-depth understanding on the local food security situation: A) local definition of food, B) local definition of food security, C) identification and definition of the different food security levels existing in the village, and finally D) the identification of community specific food security criteria (table 4). For C) food security levels and particularly for D) the identification of community specific food security criteria, the moderator aimed at deriving a consensual definition.

Only when the brainstorming of the food security criteria with farmers was exhausted, the moderator presented those criteria, which had been previously elaborated by the scientists. The relevance of these criteria to the local context was discussed with the farmers. After gaining consensus among all participants on the final set of food security criteria, the farmers were asked individually to E) weigh/score the importance of each "community specific food security criterion" (e.g., food diversity) on a scale of 0 to 5 (0=no importance, 5= very high importance) in their local context according to their individual perception. Each participant received five maize grains. The moderator asked the farmers to score the importance by indicating the grains in their covered hands such that they could not be seen by the other participants and influence others' scores. The researcher, who participated in each focus group discussion, noted the individual scorings, ensuring that they could be traced back to the participant and his/her specific characteristics, such as age, poverty situation, main occupation, and family situation. Thereafter, the maximum, minimum and average scoring results for all criteria were presented to the farmers on flipcharts, and the moderator asked for feedback, which was directly translated to the researcher. In case a farmer scored particularly high or low during the scoring rounds, but would not want to speak in front of the others, we approached this person after the focus groups individually in order to find out the reason behind the scorings.

Table 4 Systematic methodological procedure for attaining local food security criteria in farmers' workshops

Steps of the farmers workshops	Approx. time requirement	Approach
Definition: "Food"	20 minutes	Discussion of what is understood to be "food" in the village

Definition: "Food Security"	30 minutes	Discussion of what is understood to be a "food secure household"
Definition: "Food security levels"	30 minutes	Discussion of definition of the existing food security levels (classes) in the village and their characteristics
Identification of community specific food security criteria	1.5 -2.5 hours	Discussion on facts/aspects (criteria) that influence food security and the state of food security in the household.
Weighing/scoring of community specific food security criteria	1-1.5 hours	Individual scoring of the importance of criterion for food security on a scale from 0 to 5 (0=no importance, 5= very high importance). Each participant received five grains and showed the number of grains to the researcher; Presentation of final results to the whole group; Feedback round: participants commented on results.

Finally, we carried out a joint feedback round presenting the criteria results. To this end, we invited participants of the male and female focus group discussions, village heads and elders as well as the local agricultural extension officer and jointly discussed the results.

Data Analysis

The field data from the eight focus group discussions with the farmers were analysed using IBM SPSS Statistics 22. We calculated the arithmetic average of each criterion for each region, village and gender. The scoring results on a Likert item scale from 0 to 5 were ordinally scaled. For a better and more detailed interpretation of the scoring results, a calculation of the arithmetic average was necessary to enable interpretation and differentiation of the scoring results. The scoring results for each criterion were numbered from 0 to 5; they could therefore be considered as quasi-metric and were analysed as interval scaled data to calculate the arithmetic averages (Lisch 2014). The independent samples of the four villages showed non-normal distributions. To analyse the scoring result similarities and differences, we used the nonparametric Mann-Whitney U test and Kruskal-Wallis test.

After the scoring rounds the farmers were requested to comment on the quantitative scoring results. The additional information given by the farmers during and after the focus group discussions was directly translated from Swahili as well as the local language Gogo into English, hence protocolled and transcribed. The data were analysed by qualitative content analysis. We focused here on specific arguments in regard to the scoring results. The main statements of the farmers are presented in the results section.

3 Results

3.1 Food security criteria identification

Altogether, 13 food security criteria were identified by farmers across the four villages. The 13 criteria were linked to and structured along the three dimensions of sustainability i.e. social, economic and environmental. The definition of each criterion, as provided by the farmers, are listed in table 5. We further related the criteria and their local explanation to the internationally recognised food security dimensions according to their definition (WFP 2013, 2014). All four food security dimensions, availability, access, utilisation and stability, were represented by the locally identified criteria, most being related to "access" and "stability".

Table 5 Food security criteria

Criterion	Sustainability Dimension	Farmers' definition	Food Security Dimension
Food diversity	Social	Sufficient number of meals (=3) per day offering a diversified and balanced diet	Access, Utilisation
Social relations in	Social	Community support during family need (e.g., drought, family incidences such as illness, death) and share of	Access, Stability

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the community		workload (e,g, for ploughing)	
Social relations in the family	Social	Family support and understanding of decision making about households resources	Access, Stability
Working conditions	Social	Access to appropriate technology/equipment and agricultural practices, reducing working hours and workload	Access
Agronomic education	Social	Knowledge of best practices along the whole food value chain: natural resource management, production, processing, marketing and consumption	Access, Utilisation
Yield	Economic	Amount of food produced and available for family consumption and for selling	Access, Availability
Income	Economic	Family financial resources earned from agricultural production and off-farm activities	Access, Stability
Loan access	Economic	Existence of reliable and trusted institutions for loan provision for agricultural activities	Access, Stability
Market participation	Economic	Selling and buying agricultural products and other needs; knowledge of market prices for improved negotiation power of farmers towards buyers	Access, Stability
Land access	Economic	Sufficient land size and ownership of agricultural land	Access, Availability
Soil fertility	Environmental	Quality of the soil for agricultural production	Availability, Stability
Soil water availability	Environmental	Soil water availability for agricultural production	Availability, Stability
Agrodiversity	Environmental	Cultivation of crop variety for family consumption and for selling; risk management in case of crop failure	Availability, Stability

In all villages, food diversity, social relations in the community, social relations in the family, working conditions, agronomic education, yield, income, market participation, soil fertility, water availability and agrodiversity were mentioned as relevant food security criteria. The criterion of land access was discussed only in Changarawe and Idifu. In Idifu, land access, in the context of having access to a sufficient size of cultivatable land, was only mentioned during the women-only workshop. In Changarawe, access to land also referred to the size, but particularly to the unclear ownership, of the land. The majority of farmers cultivated land that was part of a former sisal estate. This fertile valley portion of land in Changarawe may be leased or sold to investors at any time for other uses by the Tanzanian government (Mwesiga Lyatuu 2013). Therefore, the planning horizon for farmer land management decisions is uncertain in this region.

The criterion loan access was not mentioned by male farmers in Ilakala in the Morogoro Region, who did not consider microfinance to be an important system because of the long saving periods that must pass before benefits are accrued and because of the small amounts that can be loaned under the current system.

3.2 Criteria ratings at a regional scale

Averaging the values across all four case study sites produced *market participation*, *working conditions*, *agrodiversity* and *water availability* as the four most important criteria. In both regions, improving farmer access to markets (*market participation*) was voiced as a major challenge to improving food security (table 6). Markets were distant from the four case study villages. Therefore, farmers were highly dependent on middlemen to sell their products. Because farmers lack information on actual market prices for their agricultural products, they do not have strong negotiation power with the middlemen. During the focus group discussion, farmers from all case study sites mentioned that they lost income because of middlemen transactions. Transport to market is costly and infrastructure is not well developed; consequently, the farmers depend on middlemen. To diversify their diet, farmers value *market access* for products that they do not produce.

Social relations either *in the community* or *in the family* were scored low in all case study sites. The farmers argued that although the community is important during shocks such as crop failure, these were exceptional.

Highly scored criteria were found across all sustainability dimensions in both regions (table 6) but criteria ratings differed between regions. Dodoma farmers prioritised criteria among the economic and environmental dimensions, whereas Morogoro farmers prioritised the social and economic dimensions.

Regional level scores for Morogoro

Focusing on Morogoro in particular (table 6), we found that *land access*, *agronomic education*, *market participation* and *food diversity* were the highest scored criteria representing the local food situation. As previously indicated, *land access* in Morogoro is a major constraint, particularly in the village Changarawe, because of insecure land ownership. *Education* was rated high; the farmers argued that they need knowledge about how to facilitate and increase their agricultural production but also how to store food. Moreover, *food diversity* was rated high. The farmers described *food diversity* as having sufficient food (three meals a day) with a good mix of staples, vegetables and fruits. Meat, as a necessary component of the regular diet, was only mentioned during the men-only workshops in both villages in the Morogoro Region.

The two lowest scoring results in Morogoro were *social relations in the community* and *loan access*. Farmers in Morogoro scored *loan access* low because of bad experiences in the village. The system was criticised more by the male farmers because of bad experiences and the misuse of savings by loaning institutions in the villages.

Regional level scores for Dodoma

In the Dodoma Region, *market participation*, *working conditions*, *water availability*, and *agrodiversity* were the four highest scoring criteria. The criterion of *working conditions* in Dodoma was mainly related to a lack of availability and access to agricultural equipment to for cultivation, such as ox ploughs. Preparing fields with a hand hoe during the dry season is difficult. Women in particular, who have the primary responsibility for cultivating the plots, complained about the hard work and the need for ox ploughs, which would allow cultivation of larger plots.

Low *water availability* caused by scarce and unreliable rainfalls is a constraint in the semi-arid agro-climate. To fetch water, women must walk long distances. *Agrodiversity* is mainly important for economic reasons, as it is a risk management strategy. The farmers grow both food and cash crops because, in the case of crop failure due to rain scarcity or pests, some crops may survive. Cash crops, such as sesame and sunflower, can be sold and may be used to augment family income.

In Dodoma, the farmers also scored *social relations in the family* low in addition to *social relations in the community*. The farmers reported that they help each other during difficult periods. However, the community "is not important for the household's calculation of food and food production" (farmer in Ilolo, 7th April 2014). In Ilakala, the farmers complained about the practices that have evolved among the families in their village. If one family lends another family food, the benefitting family has to pay back double the amount or the price of the product lent. This system was said to be practised not only among neighbours but also within extended families.

Table 6 Average criteria results at regional scale

Criteria	SD[1]	Morogoro			Dodoma			Both regions	
		Aver. (N=)	Stdev.	Rank 1-11	Aver. (N=)	Stdev.	Rank 1-13	Aver. (N=)	Stdev.
Food diversity	So	4.34*** (N=65)	1.00	3	3.60*** (N=68)	1.30	7	3.96 (N=133)	1.22
Social relations community	So	2.82 (N=65)	1.50	11	2.49 (N=68)	1.51	13	2.65 (N=133)	1.51
Social relations family	So	3.80*** (N=65)	1.34	9	2.94*** (N=68)	1.62	12	3.36 (N=133)	1.54
Working conditions	So	4.29 (N=65)	1.09	4	4.40 (N=68)	0.98	2	4.35 (N=133)	1.03
Agronomic education	So	4.35***	0.99	2	3.51***	1.41	8	3.92	1.29

		(N=65)			(N=68)			(N=133)	
Yield	Ec	4.06 (N=65)	0.92	8	3.68 (N=68)	1.31	6	3.86 (N=133)	1.15
Income	Ec	4.25*** (N=65)	0.95	5	3.32***(N =68)	1.23	9	3.77 (N=133)	1.19
Loan access	Ec	3.02* (N=46)	1.83	10	3.84* (N=68)	1.59	5	3.51 (N=114)	1.73
Market participation	Ec	4.34 (N=65)	1.16	3	4.49 (N=68)	1.09	1	4.41 (N=133)	1.12
Land access	Ec	4.40*** (N=30)	1.00	1	3.11***(N =19)	1.05	11	3.90 (N=49)	1.20
Soil fertility	En	4.09** (N=65)	1.38	7	3.13** (N=68)	1.76	10	3.60 (N=133)	1.65
Water availability	En	4.17 (N=65)	0.99	6	4.06 (N=68)	1.28	4	4.11 (N=133)	1.15
Agrodiversity	En	4.17 (N=65)	0.98	6	4.38 N=68)	0.90	3	4.28 (N=133)	0.94

* Criteria with significant differences between regions ($\alpha \leq 0.05$), **Criteria with a significant difference ($\alpha \leq 0.01$), ***Criteria with a significant difference ($\alpha \leq 0.001$). [1] SD= Sustainability Dimension; So= Social; Ec = Economic, En = Environmental

Scoring differences between Dodoma and Morogoro

We used the Mann-Whitney U test to analyse similarities and differences in criteria between the Morogoro and Dodoma Regions. Significant differences between Dodoma and Morogoro were found in the following criteria: *food diversity*, *social relations in the family*, *agronomic education* (social dimension), *income*, *loan access* (economic dimension) and *soil fertility* (environmental dimension (table 6).

All of these criteria, except for *loan access,* were scored higher by farmers in Morogoro than by those in Dodoma. According to the test, *land access* was also scored significantly differently, but the criterion was only discussed by farmers in Changarawe and in the women's workshop in Idifu. The other criteria were rated as having similar importance for food security in both regions.

3.3 Criteria ratings at village level

The scoring results per village (table 7) again show different priorities for each case study site: At Ilakala, *food diversity, income, market participation* and *water availability* were the four highest ranked criteria, whereas at Changarawe *food diversity, agronomic education, yield, land access* and *agrodiversity* scored the highest. Only *food diversity* was among the four priority criteria in both villages in the Morogoro Region. In the two villages of Ilolo and Idifu in the Dodoma Region, three of the four highest scored criteria for food security were the same: *working conditions, market participation* and *agrodiversity*. In Ilolo, the farmers identified the fourth priority as *water availability*, and in Idifu *loan access* was identified as the fourth priority.

Calculating the average results for each sustainability dimension for each of the four villages shows that the environmental dimension, comprising *soil fertility*, *water availability* and *agrodiversity*, has greater relevance for improving food security in the villages of Ilakala (average 4.31), Ilolo (average 3.85) and Idifu (average 3.87) than the social and the economic dimensions. In Changarawe, the economic dimension (4.09) comprising *yield, income, loan access, market participation* and *land access* received a higher average score than the social and environmental dimensions.

Table 7 Average results at village scale of criteria classified by the three sustainability criteria, social, economic and environmental

Criteria		Morogoro				Dodoma			
	SD	Ilakala		Changarawe		Ilolo		Idifu	
		Aver. (N=)	Stdev.	Aver. (N=)	Stdev.	Aver. (N=)	Stdev.	Aver. (N=)	Stdev.

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Food diversity	So	4.34 (N=35)	1.08	4.33 (N=30)	0.92	3.76 (N=33)	1.15	3.46 (N=35)	1.42
Social relations community	So	2.86 (N=35)	1.61	2.77 (N=30)	1.38	2.48 (N=33)	1.52	2.49 (N=35)	1.52
Social relations family	So	3.80 (N=35)	1.45	3.80 (N=30)	1.22	3.76*** (N=33)	1.23	2.17*** (N=35)	1.58
Working conditions	So	4.31 (N=35)	1.13	4.27 (N=30)	1.05	4.30 (N=33)	1.08	4.49 (N=35)	0.89
Agronomic education	So	4.17* (N=35)	1.04	4.57* (N=30)	0.90	3.39 (N=33)	1.50	3.63 (N=35)	1.33
Yield	Ec	3.69*** (N=35)	0.96	4.50*** (N=30)	0.63	3.79 (N=33)	1.32	3.57 (N=35)	1.31
Income	Ec	4.51** (N=35)	0.95	3.93** (N=30)	0.87	3.30 (N=33)	1.29	3.34 (N=35)	1.19
Loan access	Ec	2.38 (N=16)	1.89	3.37 (N=30)	1.73	3.21*** (N=33)	1.62	4.43*** (N=35)	1.34
Market participation	Ec	4.43 (N=35)	1.09	4.23 (N=30)	1.25	4.18** (N=33)	1.24	4.77** (N=35)	0.84
Land access	Ec			4.40 (N=30)	1.00			3.11 (N=19)	1.05
Soil fertility	En	4.29 (N=35)	1.36	3.87 (N=30)	1.38	3.52 (N=33)	1.77	2.77 (N=35)	1.70
Water availability	En	4.60*** (N=35)	0.78	3.67*** (N=30)	0.99	3.97 (N=33)	1.47	4.14 (N=35)	1.09
Agrodiversity	En	4.03 (N=35)	1.07	4.33 (N=30)	0.84	4.06** (N=33)	1.03	4.69** (N=35)	0.63

*Criteria with a significant difference among villages at α≤0.05), **at α≤0.01, ***at α≤0.001

The Mann-Whitney U test conducted to compare the results of the two sub-humid villages Ilakala and Changarawe (Morogoro) shows that the main differences corresponded to the following criteria: *agronomic education* (social), *yield, income* (economic) and *water availability* (environmental).

Water availability and *income* scored higher in Ilakala, whereas *education* and *yield* scored higher in Changarawe.

For the two villages Ilolo and Idifu in Dodoma, we found that the following criteria exhibited significant differences: *social relations in the family* (social), *loan access, market participation* (economic) and *agrodiversity* (environmental).

Family social relations scored higher in Ilolo than in Idifu for food security, whereas the other three criteria scored higher in Idifu than in Ilolo.

Comparing all four villages using the Kruskal-Wallis test indicates that all food security criteria, except for *social relations in the community* and *working conditions,* were scored significantly differently.

3.4 Gender-related scoring differences

Analysing the differences between male and female farmers' scores across the two regions (table 8), we identified significant differences in *social relations in community, working conditions* and for *loan access*. *Social relations in the community* were scored lower by women than by men. *Working conditions* was a criterion discussed particularly by women because they are mainly responsible for the cultivation of fields and argued that facilitating the production process could substantially enhance their work quality and agricultural production.

Focusing more closely on the differences between different gender scores within the regions (table 8), for Morogoro we found significant rating differences in *social relations in community, social relations in family, loan access*, and *land access*. The importance of *social relations in the family* and *in the community* for household food security was scored higher by men than by women. In contrast, the women scored *access to loans* and secure *access to land* higher than male farmers. In the Dodoma

Region, *working conditions* and *water availability* were scored significantly higher by women than by men.

When analysing female and male farmer scores by village, we also found significant differences: in Ilakala, only *soil fertility* was scored significantly differently, with male farmers considering it to be more important. In Changarawe, we found *social relations in the community* and *social relations in the family*, were scored significantly higher by men, whereas *loan access, access to land,* and *soil fertility* were scored significantly higher by women. In Ilolo, only *working conditions* was scored significantly higher by women than by men. In Idifu, *social relations in the family, loan access* and *water availability* were scored significantly higher by women than by men.

4 Discussion

4.1 Food-security-relevant criteria and their context relatedness

Criteria scores in the four case study villages

The analysis of the focus group discussions in the four case study villages resulted in a set of food security criteria (table 5). The majority of the criteria were related to improving agricultural production (food availability and access) and avoiding losses (food stability), indicating that many rural households depend on their own agricultural production for food. This finding was also emphasised by the "Comprehensive Food Security and Vulnerability Analysis Tanzania 2012" (WFP 2013), which identified productivity and market access challenges as contributors to smallholder food insecurity. The report stated that the main challenges were: lack of mechanisation; the need for agricultural inputs, water availability, farmer knowledge and skills for improved agricultural technology; and access to loans to purchase technology and inputs.

We found the main challenges in achieving food security to be similar among all four case study sites; however, the scores for the importance of criteria for differed substantially among each case study site (table 7). We assume this result to be related to the local context determining the main food security challenges. For instance, the village Changarawe in the Morogoro Region is more developed because it is close to the district capital Kilosa. Here, farmers have access to agricultural inputs and can sell their products at the district food market. In contrast, the village Idifu in the semi-arid Dodoma Region is located far from any town and any food markets where farmers can sell their agricultural production. Consequently, *market access* was scored highest by farmers in Idifu.

Land access is another example of the content relatedness in scoring. *Land access* is the basis of the farmers' livelihood because it is the prerequisite for agricultural production (Mazoyer 2001; Quan 2006; FAO 2011; Narayan et al. 1999). For several years, land ownership has been a controversial issue in Changarawe because the majority of farmers cultivate land that is part of a former sisal estate, and this area may be leased or sold to investors at any time for other uses by the Tanzanian government. This situation leaves farmers in a state of uncertainty and fear regarding their food security (Mwesiga Lyatuu 2013). In the other three villages, access to land is currently not a controversial issue and was therefore not an object of discussion.

The social cohesion in the villages with respect to food security is not very important. *Social relations in the community* was rated low in all villages. Farmers stated that food is managed at a household level and that only in highly urgent situations do they borrow food from neighbours. The low rating of *social relations in the family* in Idifu was mainly discussed with respect to decision making related to food and food expenditures between women and men in one household. Whereas the men in Changarawe mentioned that conflicts between women and men would have negative impacts on household food security, the men in Idifu mentioned that women would not have the right to interfere and decide on these issues; therefore, those relations at the household level, particularly between women and men, do not affect food security. In Changarawe, women said that they actively claim their right to be involved in decision making, which might be related to the fact that Changarawe has benefitted from different development projects initiated by international agencies. Gender justice is a mainstream issue in international agency approaches, and farmers in Changarawe may have been sensitised in this regard. Ilolo and Idifu have not yet benefitted from international development interventions (UN-Women 2014; FAO 2011).

The arguments presented by the farmers underline their scores, showing that farmers themselves know their locality best (Chambers 1995). They provided detailed information on the local challenges and complex cause-effect linkages in agricultural production, in contrast to quantitative reductionist approaches, which often leave much room for interpretation (Neef and Neubert 2011; Schindler et al. 2015; Sumberg et al. 2003). The realities of farmers are local, complex, diverse and dynamic. Our research showed the multidimensionality of food security from the farmers' perspective. Furthermore, the interactive participatory approach taken with the farmers provided valid insight into values, priorities and preferences. Only when further development measures respond to and respect these values, priorities and preferences in local contexts will they have the potential to be successful (Chambers 1995, 2012).

Gender differentiated perception of food security

Our approach also supports the need to consider priority differences with different target groups in a community. We found that female and male participants scored the criteria differently. Men considered intact *social relations in the community* and *in the family* more important for food security than women did. Women scored several production-related aspects as more important than men did: for example, *working conditions* (in Dodoma and Morogoro), *land access* (Morogoro), *loan access* (Morogoro) and *water availability* (Dodoma), indicating their high level of responsibility for agricultural production. Therefore, measures for improving agricultural production should strongly integrate the knowledge, role and constraints of women and recognise that women perform 60–80% of agricultural labour (FAO 2011; Croppenstedt et al. 2013; Ezezika et al. 2013). Therefore, knowing what is really required by whom in a specific area helps to anticipate what measures would be needed to improve food security (FAO 2011).

Brainstorming of food security criteria with scientists and farmers

Considering the different sets of food security criteria derived during the scientists' brainstorming workshop and the farmers' focus group discussions (tables 2 and 5), we found several similarities, but also particular differences. Some criteria were considered by both, for instance, *soil fertility*, *yield* or *income* while others such as *working conditions*, *loan access*, and *land access* were considered only by farmers and further criteria such as *gender balanced empowerment* and *labour access/availability* only by researchers. Furthermore, during feedback sessions, scientists found that several farmers' perceptions were unknown to them, again supporting the importance of knowledge co-generation (Chambers 2012). Only the farmers themselves can indicate their understanding of the locally relevant food security criteria (table 5). Hence, it is through such a participatory process with active community involvement that co-generation of knowledge of locally specific information is possible (Chambers 2012, 1994b; Agol et al. 2014). Many interrelationships and much local information are simply invisible to researchers, whereas based on the daily challenges they face communities have a more holistic view of their livelihoods (Millstone et al. 2010).

4.2 Linking sustainable development and food security

Our findings support the need to link sustainability and food security in agricultural development (IAASTD 2009; Cavatassi 2010; FAO 2013). The criteria were grouped under the social, economic and environmental dimensions of sustainability. Five criteria (*food diversity, social relations in the community, social relations in the family, working conditions and education*) represent the social dimension. Four to five criteria (*yield, income, loan access, market participation and land access [land access only in Changarawe and Idifu]*) represent the economic dimension. Three criteria (*soil fertility*, *water availability* and *agrodiversity*) represent the environmental dimension. This alignment shows that rural communities think holistically and consider multiple criteria and dimensions when assessing their particular food security situation (Millstone et al. 2010). Organising the criteria along the three sustainability dimensions (social, economic and environmental) facilitated a structured analysis and helped to identify which dimension, social, economic or environmental, was given the highest priority for improving food security (table 6 and 7). At all four case study sites, one or more criteria per sustainability dimension were rated as very important for food security, highlighting the need to consider all three dimensions to find solutions (López-Ridaura et al. 2002; Schindler et al.

2015; Hacking and Guthrie 2008; Bond and Morrison-Saunders 2011; Bond et al. 2012). Calculating the average value of the criteria across each sustainability dimension (table 7) indicates that environmental aspects were ranked higher for improving food security than social and economic aspects in Ilakala, Ilolo and Idifu, whereas in Changarawe, priority was given to economic aspects.

Linking the criteria to food security dimensions, we found that most of the criteria could not be simply attributed to a single food security dimension. Regarding the farmers' definition, interrelations between the dimensions, e.g., the criterion soil fertility is related to the two dimensions availability and stability, were observed (table 5). According to the FAO (2008) "[…] for food security objectives to be realised, all four dimensions must be fulfilled simultaneously". Our results show that all dimensions are represented, but each local community does not set the same priority for each dimension. The criteria, as indicated by the farmers, demonstrate the close interrelationship between sustainability and food security.

4.3 Methodological Approach

We found our methodological approach to support a constructive and interactive way of elaborating locally relevant food security criteria. The focus group discussion helped support group exchange, generate knowledge and make research relevant by addressing local needs. The focus group discussions, which were separate for male and female farmers, were beneficial for collecting information about what is locally and gender-specifically perceived as food security and for identifying the relevant food security issues (criteria). Jackson and Kassma (1998) describe how "women are systematically excluded", their "[…] voices are muted and their priorities remain invisible in participatory evaluations." During some of the joint feedback rounds, with men and women together, we also observed how women did not speak freely and even refused to speak when the moderator approached them directly, even though the same women had spoken freely during the female workshop the day before. Brainstorming about food security criteria in separate women-only and men-only workshops helped in collecting ideas and responses from respondents without judgement (Pretty et al. 1995). The method of scoring the criteria on an individual basis allowed for many different opinions to be captured, illustrating how radically different perceptions can be and what similarities exist (Pretty et al. 1995). Furthermore, we minimised the influence of dominant characters, as often occurs in social research during focus group discussions (Jakobsen 2012). The diversity and range of scoring results among the criteria (table 7 and 8) indicated the individual character of the scores. The final feedback discussion also indicated the ranges and extremes of the scoring results for each criterion, triggering discussion among the farmers.

By knowing the single scoring results, we found that the comments in the group sessions were not necessarily shared opinions (Jakobsen 2012). Therefore, we approached several farmers individually after the focus group sessions to gain unfiltered, detailed information. During the group sessions, we also observed the importance of local experienced moderators who fluently speak the local language, including local dialects, and that he/she should have great empathy, making the farmers feel that they are listened to and taken seriously (Chambers 1995, 2012; Reed 2008). The atmosphere in most workshops was lively and open. To conclude, with our participatory approach, we produced a set of locally relevant food security criteria that covers the holistic view of farmers on food security. This set of criteria helped us to gain new insights and understanding of farmers' knowledge, priorities and perspectives as they were actively and respectfully involved in the process (Chambers 2012; López-Ridaura et al. 2002).

4.4 Outlook

As emphasised by Agol et al. (2014), Bell and Morse (2008), and Catley et al. (2007), food security criteria must be context-related because communities have their own priorities for improving their lives (Catley et al. 2007; López-Ridaura et al. 2005). Hence, the active involvement of communities is essential to the criteria development process.

This participative approach for deriving locally adapted food security criteria is essential and a prerequisite for adapting project and program planning for existing local development priorities (Vink 2012) and for supporting the identification of possible trade-offs of planned interventions (Morris et al. 2011; König et al. 2012; König et al. 2013). The jointly developed criteria can be used for a) impact assessment, b) monitoring, and c) evaluation of development measures (López-Ridaura et al. 2005; Cosyns et al. 2013). This participatory process helps develop adapted solutions by addressing the needs and challenges defined by the target group. Our methodological approach is easily applicable and can also be used in other localities to derive locally relevant food security criteria.

We will further use these criteria as a basis for participatory impact assessments of agricultural development measures. Based on the impact assessment outcomes, the agricultural measures can be better adapted to priorities as perceived by the target group at the different case study sites. This effort will significantly add to farmers' ownership and identification with the development measures (Long 2010; Chambers 1994a, 1994b).

5 Conclusion

Our participatory methodological approach supported a constructive and interactive way of co-generating knowledge to elaborate locally relevant food security criteria. The setting of gender-separated focus group discussions with the farmers was beneficial in collecting individual locally relevant information and perceptions on food security. We arrived at a meaningful set of 13 criteria: (1) *food diversity,* (2) *social relations in the family and* (3) *in the community,* (4) *working conditions,* (5) *education,* (6) *yield,* (7) *income,* (8) *loan access,* (9) *market participation,* (10) *land access,* (11) *soil fertility,* (12) *water availability,* and (13) *agrodiversity*. The reasons and complex cause-effect linkages noted by the community members support the scoring results. Scoring the food security criteria on an individual basis allowed us to capture the many diverse opinions and priorities of farmers and their main challenges in improving food security in their local agricultural context. A structured analysis categorising the criteria into the three sustainability (social, economic, environmental) and the four food security (availability, access, utilisation, stability) dimensions indicated that the criteria are strongly interrelated, highlighting that the communities have a holistic view of food security. These food security criteria can be applied in impact assessment, monitoring and evaluation, as well as for trade-off analysis of local agricultural development measures.

Table 8 Gender-related scoring results

Criteria	Both regions				Morogoro				Dodoma			
	Female		Male		Female		Male		Female		Male	
	Aver. (N=)	Stdev.	Aver. (N=)	Stdev.	Aver. (N=)	Stdev.	Aver. (N=)	Stdev.	Aver.(N=)	Stdev.	Aver. (N=)	Stdev.
Food diversity	4.05 (N=66)	1.12	3.88 (N=67)	1.31	4.35 (N=31)	1.05	4.32 (N=34)	0.98	3.77 (N=35)	1.11	3.42 (N=33)	1.46
Social relations community	2.38* (N=66)	1.38	2.91* (N=67)	1.59	2.35* (N=31)	1.56	3.24*(N=34)	1.33	2.40 (N=35)	1.22	2,58 (N=33)	1.79
Social relations family	3.24 (N=66)	1.38	3.48 (N=67)	1.69	3.26** (N=31)	1.48	4.29**(N=34)	0.97	3.23 (N=35)	1.31	2.64 (N=33)	1.87
Working conditions	4.53* (N=66)	0.86	4.16* (N=67)	1.15	4.39 (N=31)	0.99	4.21 (N=34)	1.18	4.66* (N=35)	0.73	4.12* (N=33)	1.14
Agronomic education	4.06 (N=66)	1.16	3.79 (N=67)	1.40	4.42 (N=31)	0.85	4.29 (N=34)	1.12	3.74 (N=35)	1.31	3.27 (N=33)	1.49
Yield	3.71 (N=66)	1.15	4.01 (N=67)	1.14	4.00 (N=31)	0.93	4.12 (N=34)	0.91	3.46 (N=35)	1.27	3.91 (N=33)	1.33
Income	3.71 (N=66)	1.09	3.84 (N=67)	1.29	4.26 (N=31)	0.97	4.24 (N=34)	0.96	3.23 (N=35)	0.97	3.42 (N=33)	1.46
Loan access	3.85* (N=66)	1.63	3.04* (N=48)	1.77	3.52** (N=31)	1.88	2.00 ** (N=15)	1.25	4.14 (N=35)	1.33	3.52 (N=33)	1.79
Market participation	4.41 (N=66)	1.05	4.42 (N=67)	1.20	4.10 (N=31)	1.25	4.56 (N=34)	1.05	4.69 (N=35)	0.76	4.27 (N=33)	1.33
Land access	3.85 (N=34)	1.26	4.00 (N=15)	1.07	4.80** (N=15)	0.78	4.00** (N=15)	1.07	3.11 (N=19)	1.05		
Soil fertility	3.59 (N=66)	1.67	3.61 (N=67)	1.64	4.13 (N=31)	1.34	4.06 (N=34)	1.43	3.11 (N=35)	1.81	3.15 (N=33)	1.73
Water availability	4.21 (N=66)	1.18	4.01 (N=67)	1.11	4.06 (N=31)	1.00	4.26 (N=34)	0.99	4.34** (N=35)	1.33	3.76** (N=33)	1.17
Agrodiversity	4.18 (N=66)	0.98	4.37 (N=67)	0.90	4.10 (N=31)	0.98	4.24 (N=34)	0.99	4.26 (N=35)	0.98	4.53 (N=33)	0.80

* Criteria with significant difference at $\alpha \leq 0.05$, **, $\alpha \leq 0.01$, *** $\alpha \leq 0.001$

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4.2 2nd Paper: Sustainability impact assessment to improve food security of smallholders in Tanzania

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Sustainability impact assessment to improve food security of smallholders in Tanzania

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ABSTRACT

The objective of this paper was to assess the sustainability impacts of planned agricultural development interventions, so called upgrading strategies (UPS), to enhance food security and to identify what advantages and risks are assessed from the farmer's point of view in regards to social life, the economy and the environment. We developed a participatory methodological procedure that links food security and sustainable development. Farmers in four different case study villages in rural Tanzania chose their priority UPS. For these UPS, they assessed the impacts on locally relevant food security criteria. The positive impacts identified were mainly attributed to increased agricultural production and its related positive impacts such as increased income and improved access to necessary means to diversify the diet. However, several risks of certain UPS were also indicated by farmers, such as increased workload, high maintenance costs, higher competition among farmers, loss of traditional knowledge and social conflicts. We discussed the strong interdependence of socio-economic and environmental criteria to improve food security for small-scale farmers and analysed several trade-offs in regards to UPS choices and food security criteria. We also identified and discussed the advantages and challenges of our methodological approach. In conclusion, the participatory impact assessment on the farmer level allowed a locally specific analysis of the various positive and negative impacts of UPS on social life, the economy and the environment. We emphasize that only a development approach that considers social, economic and environmental challenges simultaneously can enhance food security.

1. Introduction

Sustainable agricultural development is linked to the improvement of food security and poverty alleviation, especially in developing countries, where 98% of the chronically hungry population lives (WSSD, 2002; FAO, 2013). In Africa, 90% of agricultural production is derived from smallholder farmers, where the average farm size is about one hectare (IAASTD, 2009; IFAD and UNEP, 2013). These smallholder farmers represent the poorest and most hungry population group in developing countries (IAASTD, 2009; Dethier and Effenberger, 2012; IFAD and UNEP, 2013). Several development initiatives focus on enhancing the agricultural production and productivity of smallholder farmers. The possible impacts of these development initiatives need to be assessed before implementation to minimize negative impacts and the risk for failure as well as to maximize the potential for livelihood improvement. With the help of ex-ante impact assessment, negative side effects may be discovered, which are invisible from the external points of view of development organizations or researchers who are planning development interventions (EIARD, 2003; Millstone et al., 2010). Ex-ante impact assessment has become an important tool to assess the performance of sustainable development as part of the planning process, i.e., before policy or project implementation (Helming et al., 2011). Sustainability impact assessment is the process that aims to direct decision making towards sustainability (Hacking and Guthrie, 2008; Bond and Morrison-Saunders, 2011; Morrison-Saunders et al., 2014). There is a need to develop a methodological approach that links food security and sustainable agricultural development. This is essential to adapt agricultural development interventions to enhance food security to the local context and to steer towards sustainable development (Schindler et al., 2015). In recent years, impact assessment has become an increasingly important aspect of development activities, as agencies, and particularly aid donors, have sought to ensure that funds are well spent (Hulme, 2000). There is a great emphasis on the suitability and sustainability of project interventions, and assessing these qualities requires

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appropriate methods. As highlighted by Mayoux and Chambers (2005), the new impact assessment agenda for pro-poor development and improving practise necessarily require participation by poor women and men in deciding priorities and identifying upgrading strategies (UPS).[1] Schindler et al. (2015) and Becker et al. (2003) highlight that the active involvement of different stakeholder groups throughout the assessment process and the possibility of learning and exchange are fundamental to impact assessment towards sustainability. Participatory methods are powerful and are indeed essential for identifying the most relevant local indicators to be measured.

Impact assessment remains dominated by quantitative approaches (Mayoux and Chambers, 2005). There is a lack of participatory methodological frameworks that are easily applicable and that link sustainable agricultural development and food security. In this study, we developed a framework for the application at a local level with small-scale farmers; the framework links sustainability and food security with the goal of being applicable in different geographical contexts, particularly in developing countries. We applied the framework at four different case study villages in rural Tanzania to assess the sustainability impacts of planned agricultural UPS to enhance food security and to identify the positive and negative impacts; the advantages and risks are assessed from the farmer's point of view in regards to social life, economy and the environment.

2. Methods and materials

2.1. Study area

This study was carried out in four Tanzanian villages: Ilakala, Changarawe, Ilolo, and Idifu. These villages are located in two regions: Dodoma and Morogoro. The villages Ilakala and Changarawe are located in the semi-humid Morogoro Region in the Kilosa District. Ilolo and Idifu are situated in the semi-arid Dodoma Region in the Chamwino District. The two regions represent the majority of farming systems in Tanzania (USAID, 2008). The food systems in the predominantly semi-humid (600–800 mm) Morogoro Region are more diverse and are primarily based on maize, sorghum, legumes, rice and horticulture and partly based on livestock. In the semi-arid (350–500 mm) Dodoma Region, the food system is primarily based on sorghum and millet, with a long history of livestock husbandry (Mnenwa and Maliti, 2010). Food and livelihood security in the case study villages in Dodoma and in Morogoro depend on sufficient and well distributed rains (USAID, 2008). Approximately 35% of the population in Morogoro and only approximately 21% in Dodoma are engaged in non-farm agriculture. The Dodoma Region is particularly sensitive to food insecurity, whereas Morogoro has both food-insecure and food-secure areas. In Tanzania, Dodoma has, by more than 80%, the highest rate of stunted children under five years old. The level of child stunting in Morogoro is slightly above the Tanzanian national level of approximately 60% (URT, 2011b). In both regions, the population density is less than 50 persons per square kilometre (URT, 2006). The annual population growth rate is higher in Morogoro (2.6) than in Dodoma (2.2). In Morogoro, approximately 17.9% of men and 24.2% of women have no access to education, while in Dodoma, it is even higher, at 33.2% of the males and 39.6% of the females (URT, 2011a).

2.2. Framework for participatory impact assessment

The methodological approach used for the UPS impact assessment is based on the Framework for Participatory Impact Assessment (FoPIA). Originally, the FoPIA was designed to complement quantitative computer-based sustainability impact assessment tools in the European context with a qualitative participatory approach (Helming et al., 2011) and was first described by Morris et al. (2011). Simultaneously, the

[1] Upgrading strategy (UPS) is a best practise which aims at enhancing food security in the local context.

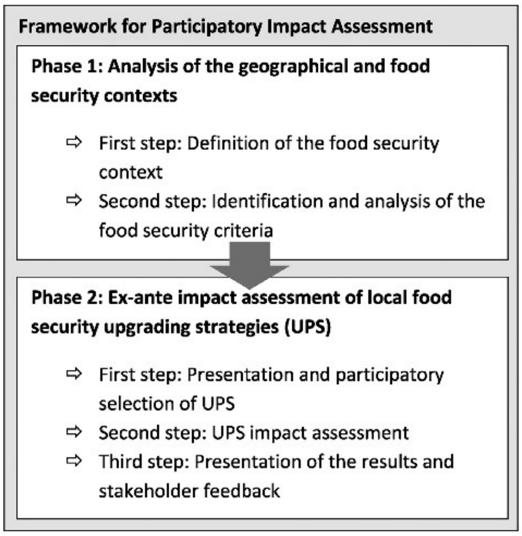

Fig. 1. Adapted schema of the FoPIA.

FoPIA was adapted and further developed by König et al. (2010) to be applicable in the context of developing countries (König et al., 2012, 2013; Purushothaman et al., 2012). The FoPIA provides a general assessment framework with a sequence of methods for conducting sustainability impact assessment in different regional contexts (Morris et al., 2011). However, it has mainly been applied to assess alternative land use policies at the policy maker level in different regional contexts (König et al., 2013).

In this study, the FoPIA was further developed to be applicable at the community level to adapt food security strategies to the local conditions and needs. The objective is that the local population assesses the impacts of proposed agricultural UPS before their implementation. With the help of impact assessment, the main challenges of interventions are analysed, providing the opportunity to select, adapt and modify measures (Silvestrini, 2011; Schindler et al., submitted for publication). To be applicable at the rural community level, the methods used must be comprehensive and must consider local cultural conditions (Mayoux and Chambers, 2005; Reed, 2008). This modified FoPIA comprises two main parts: 1) analysis of the geographical and food security contexts; and 2) ex-ante impact assessment of local food security UPS. The following methodological steps are a series of successive participatory workshops (see Fig. 1).

2.2.1. Phase 1: analysis of the geographical and food security contexts

The first phase of this methodological approach focuses on understanding the local context and the food security situation (Reed, 2008). The focus here is on the local understanding and definition by the local population rather than on descriptions based on a literature review and secondary data.

⇨ *Phase 1: first step: definition of the food security context*

At each case study site, we conducted focus group discussions with women and men; each were held separately with 15 to 19 participants (Schindler et al., submitted for publication). The criteria used to guarantee a diverse selection of participants who represented the village community were as follows: (I) representation of all sub-villages; (II) different age groups (young: age 15–25 years, adults, elderly people: age > = 60 years); (III) persons of different marital statuses (married, single, widow); (IV) a diversity of major occupations practised at the case study site (farming, pastoralism, activities other than farming); (V) the economic status of the household (poor, moderate, better off); (VI) the diversity of land ownership (rent, own, none); and (VII) a mixture of participants who are household heads and those who are not. The farmers first defined their understanding of food security in their local environment. Then, they discussed the different food security class levels in the village and defined their characteristics.

⇨ *Phase 1: second step: identification and analysis of the food security criteria*

Once the food security situation was analysed, the farmers identified community-specific food security criteria. In preparation for this process, literature review on food security criteria was done (EC and FAO, 2008; FAO, 2009, 2013; WFP, 2014; Crewett et al., 2011) and a workshop was carried out with international and Tanzanian researchers, developing a first draft of locally relevant food security criteria. However, the workshop began with open brainstorming by the farmers without any input by the researchers. The farmers were asked about challenges that influence the local food situation. Those challenges were translated into criteria in a discussion with the workshop participants. When open brainstorming was exhausted, the criteria elaborated by the researchers were introduced and discussed, in case they were not already mentioned by the farmers themselves. Subsequently, the farmers individually scored the importance of each criterion for food security in the local context (0 = no importance to 5 = very high importance). Each participant received five grains. The scoring results from each participant were collected by the researcher. The average weighing results were presented back to the farmers, and the moderator introduced a discussion on the reasons behind the results.

After the workshops at all four case study villages, 13 food security criteria were identified (Schindler et al., submitted for publication). For the practicability of the impact assessment process, we reduced the number of criteria from 13 to 10 by combining *social relations in the community* and *social relations in the family* to "social relations", by removing *land access* because it was a problem specific to Changarawe and is therefore not comparable with the other villages, and by reducing *loan access*, which was sufficiently covered for the impact assessment by *income*. The final set of criteria was linked to and structured along the three sustainability dimensions. The more specific description of these criteria for food security (Table 1) was given by the farmers during the workshops (Schindler et al., submitted for publication).

Table 1
Food security criteria and explanation (adapted from J. Schindler et al., 2015).

Criterion	Sustainability dimension	Definition and regional relevance
Food diversity	Social	Sufficient number of meals (=3) per day offering a diversified and balanced diet
Social relations	Social	Community support during family need (i.e., drought, family incidences such as illness, death) and share of the workload (i.e., field ploughing), Family support and understanding of decision-making about households resources
Working conditions	Social	Access to appropriate technology/equipment and agricultural practises, reducing working hours and workload
Agronomic knowledge	Social	Knowledge on best practises along the whole food value chain: natural resource management and production, processing, marketing, consumption
Yield	Economic	Amount of food produced and available for family consumption and for selling
Income	Economic	Family financial resources earned from agricultural production and off-farm activities
Market participation	Economic	Selling and buying agricultural products and other needs; knowledge of market prices for improved negotiation power of farmers towards buyers
Soil fertility	Environmental	Quality of the soil for agricultural production
Water availability	Environmental	Soil water availability for agricultural production
Agrodiversity	Environmental	Cultivation of crop variety for family consumption and for selling; risk management in case of crop failure

2.2.2. Phase 2: impact assessment of local food security upgrading strategies

After the elaboration of the relevant criteria for food security, they were used for the impact assessment of agricultural UPS. The approach followed in the Trans-SEC project is the elaboration of UPS along the food value chain with the following four components: 1) *natural resource management and crop production* (*NRM/crop production*); 2) *post-harvest processing and biomass/energy surplus* (*processing/energy supply*); 3) *markets and income generation* (*markets*); and 4) *consumption*. For each component, three to five UPS were developed in a participatory process, with the primary goal of enhancing food security (Graef et al., 2014, 2015a, 2015b). The method and the results of the impact assessment of the identified UPS on the researcher/expert level were published by Uckert et al. (submitted for publication). For the impact assessment of the UPS on the local farmer's level, we organized four workshops in each village. A minimum of 9 to a maximum of 13 people participated in each workshop. One workshop group treated the UPS of one of the four food value chain components. For the impact assessment, we invited farmers to participate according to the following criteria: (I) their competence, experience and knowledge regarding the food value chain component and related UPS; (II) their knowledge on the agricultural practises in the village; (III) the representation of different sub-villages; (IV) a mixed representation of gender (app. 50% women and 50% men); (V) a representation of different age groups (young: age 15–25 years, adults, elderly people: age = above 60 years); (VI) the economic status of the household (poor, moderate, better off); and (VII) that "stakeholder participants should not be too dominant due to their hierarchical position".

⇨ *Phase 2: first step: presentation and selection of upgrading strategies (UPS)*

The UPS related to each food value chain component were presented to the farmers (Table 2). To support the comprehensiveness of the UPS, the experts used picture material and a flipchart for an interactive presentation. Then, the participants were separated to work in small, moderated working groups on a SWOT (strengths, weaknesses, opportunities, threats) analysis for each UPS. Each group presented the working results in a common presentation to the other workshop participants. The farmers chose priority UPS related to each food value chain component for final implementation (Table 3). To select the priority UPS, each farmer received ten grains and individually distributed the grains among the UPS options according to their priorities in a secret voting ballot. The average of points given by the workshop participants were presented to the group, and their feedback on their choice of UPS was discussed. The priority UPS entered into the impact assessment.

⇨ *Phase 2: second step: UPS impact assessment*

The objective during this process was for the farmers to rank their assumed impacts of the UPS on each of the food security criteria. The participants were requested to think about the positive and negative impacts that the UPS may have according to each criterion and to rate the impact on a scale from +3 to −3 (+3 high positive impact, +2 moderate positive impact, +1 small positive impact, 0 no impact, −1 small negative impact, −2 moderate negative impact, −3 high negative impact). During pretesting of the method in Tanzania, we discovered that performing the positive and negative rating of impacts at the same time seemed to be difficult for the farmers. Therefore, we decided to first conduct a positive impact rating round followed by an assessment of the negative impacts. Each farmer held three grains in one hand. The moderator went criterion by criterion; for example, for the impact on the criterion *social*

Table 2
Upgrading strategies of each food value chain component, as treated by different groups (adapted from Uckert et al., submitted for publication).

Group 1: Natural resource management/crop production

1 Rainwater harvesting (RWH): In-situ RWH using tied ridges in the sub-humid region and infiltration pits in the semi-arid region (Mahoo et al., 2012)
2 Fertilizer micro-dosing: Micro-dose rates of 5–6 kg P/ha (2–5 g/hill as NPK) placed 4–8 cm away and lateral to the seeds, with higher rates in more humid climates (Bagayoko et al., 2011)
3 Optimized weeding: weeding targeting soil water conservation and the suppression of parasitic weeds through better timing (Hayelom, 2014)

Group 2: Post-harvesting processing and biomass/energy supply

1 By-products for bioenergy: Low-cost (300$) pyrolyser (manufactured from a 100–200 l oil barrel) producing charcoal from Maize cobs and simultaneously used for cooking (Ikele and Ivoms, 2014)
2 Improved processing devices: mobile maize shelling machines in the sub-humid region and millet winnowing machines in the semi-arid region, including a business plan for investment and pay-offs (Mejia, 2003)
3 Improved wood supply: Tree planting in various niches (farm boundaries, woodlots, natural regeneration in-field) using tree nurseries (Kimaro et al., 2007)
4 Improved stoves: Small-scale stoves reducing energy consumption from loam for household use with one or two holes at 3–5 US$/stove, locally constructed by trainers training other stakeholders (Kshirsagar and Kalamkar, 2014)
5 Manure and biogas: bio-digesters for sustained biogas production using cow manure; additionally, the produced bioslurry is a very healthy organic fertilizer

Group 3: Markets and income generation

1 New product development: Enhanced horizontal and vertical coordination of sunflower oil production, including investment in sunflower oil press (RLDC, 2008)
2 Optimized market oriented grain storage: Using low-cost IRRI airtight superbags (Rohitha Prasantha et al., 2014)
3 Poultry-crop integration: Poultry keeping, disease management, crop by-product utilization in raising poultry, poultry manure utilization (Mlozi et al., 2003)
4 Market access system (m-IMAS): mobile phone-based online market for farmers marketing their produce at better prices and for buyers (Kadigi et al., 2013)

Group 4: Consumption

1 Household nutrition education: Increase awareness of nutrient-rich indigenous foods and making better use of their crops (Roy et al., 2005)
2 Kitchen garden training: cultivating indigenous fruits and vegetables for dietary diversification (Galhena et al., 2013)
3. The processing, preservation, and storage of fruits and vegetables: Practical demonstrations on using the improved technologies (improved sun drying, the construction and use of locally made solar panels, drying under shed after blanching vegetables, etc.)

relations, the question was stated as follows: "Can you think of any positive impact on social relations caused by the rainwater harvesting measure "tied ridges"? If yes, how strong will this upgrading strategy positively influence the social relations on a scale from +1 to +3? If you estimate that there is no positive impact, it is 0". The farmers held the grains in their hands, invisible to their neighbouring farmers. After the positive rating round was finished, the moderator restarted the process for the negative impacts. Once the two rating rounds were finalized, the average results and the minimum and maximum impact scores of the UPS on each criterion were presented to the group. The moderator went criterion by criterion to ask the reasons behind the positive and negative assessment results. After the group feedback was provided, it was possible to conduct some individual interviews to identify additional reasons for the rating results.

⇨ *Phase 2: third step: presentation of the results and stakeholder feedback*
In a final presentation, all the results were presented officially in front of village elders and authorities. The UPS were presented, and the impact assessment results were shortly summarized. In a moderated process, the linkages between the UPS were discussed, and the stakeholders were asked for the feedback and add-on activities necessary for the successful implementation of UPS. The results were discussed, and the plan of timing and distribution of responsibilities for the implementation of UPS were announced.

Table 3
Upgrading decision in all four case study villages.

	NRM/crop production			Processing/energy supply					Markets				Consumption		
	Rainwater harvesting	Fertilizer micro-dosing	Optimized weeding	By-products for bioenergy	Improved processing devices	Improved wood supply	Improved stoves	Biogas Manure	Market access system (m-IMAS)	Poultry-crop integration	Optimized market oriented grain storage	New product development	Household nutrition education	Kitchen garden training	Storage and conservation
Ilakala	X	X		X	X						X		X		
Changarawe	X		X		X		X			X			X		
Idifu	X	X			X		X					X	X		
Ilolo	X	X			X	X						X	X		

2.3. Data analysis

The field data of the impact assessment were analysed with IBM SPSS Statistics 22. We calculated the arithmetic average and standard deviation of the assessed impacts for all selected UPS. For a better and more detailed interpretation of the scoring results, a calculation of the arithmetic average was necessary to enable interpretation and differentiation of the scoring results. The scoring results for each criterion were numbered on a Likert Scale from 0 to 3 and were considered as quasi-metric. The results were analysed as interval scaled data to calculate the arithmetic averages (Lisch, 2014). The independent samples of the four villages had non-normal distributions. To analyse the scoring result similarities and differences, we used the nonparametric Mann–Whitney U-test.

3. Results (phase 2: second step: UPS impact assessment)

3.1. Participatory selection of upgrading strategies

The farmers in the four case study villages chose two UPS related to the food value chain components, *NRM/crop production* and *processing/energy supply*, and one UPS each for *markets* and for *consumption* (Table 3).

3.2. Impact assessment of local food security upgrading strategies

Below, we present the results of Phase 2: Second step: UPS Impact Assessment. We present the results for each village and for each food value chain component.

3.2.1. Assessment results for the food value chain component NRM/crop production

In *Ilakala*, the participants in the workshop ranked the impacts of the rainwater harvesting measure "tied ridges" on all criteria high during the positive assessment round. The impacts of tied ridges were assessed as the most highly positive on the economic dimension (+2.93), followed by the social (+2.92) and the environmental dimension (+2.89). The highest positive assessments were on *yield*, *income*, *food diversity* and *water availability*. The positive impacts were all related to a higher yield because of the increased water availability. For *working conditions* only, the farmers in Ilakala assessed a negative impact, which was ranked higher by women (Ø −2.0) than by men (Ø −0.6).

The impacts of *fertilizer micro-dosing* on all criteria were ranked high, on average, during the positive rating round. The highest positively assessed impact was on economic criteria (+3.00), closely followed by the environmental (+2.93) and social dimensions (+2.92). The highest assumed impacts were on *yield*, *income*, *market participation*, *food diversity*, *social relations*, *agronomic knowledge* and *soil fertility*. The positive assessments were also all related to increased yields because of fertilizer application. Negative impacts were assessed for *working conditions* (−0.17) and *water availability* (−0.11). The farmers stated that fertilizer micro-dosing is both time and work-intensive and that fertilizer may harm production during drought years.

In *Changarawe*, the assessment results for "tied ridges" during the positive round were highest on the environmental dimension (+2.91), followed by the social (+2.89) and economic dimensions (+2.67). Positive assessments were particularly high for *food diversity*, *agronomic education*, *water availability* and *agrodiversity*. The farmers also identified several risks of rainwater harvesting on all dimensions, mainly on economic criteria (−1.39) but also on environmental (−0.40) and social criteria (−0.39), namely the following: *yield*, *income*, *market participation*, *social relations*, *working conditions*, *agronomic knowledge*, *soil fertility*, *water availability*, and *agrodiversity*. The given reasons for negative assessments were that the measure is time and work-intensive and that it is a great waste of resources during drought years. Additionally, in the case that all surrounding farmers produce more yield, the market price will be negatively affected. Surplus income from higher yields could create conflicts in families because of mismanagement of the money. Traditional techniques might be lost.

For optimized weeding, assessments were very high for the environment (+2.97), followed by economic (+2.82) and social criteria (+2.57). The highest positive assessments were identified for *income*, *social relations*, *agronomic knowledge*, *water availability* and *agrodiversity*. The reasons were mainly based on higher production. During the negative assessment round, the risks were assessed in regards to the economic (−0.18) and social (−0.07) sustainability dimensions, particularly for *income*, *market participation*, and *social relations*. The reasons were that *optimized weeding* is labour and time intensive and requires financial input and that increased yield also causes the market price to decrease. Work efficiency is lost, and less land can be prepared for cultivation. On one hand, more income has beneficial effects for social relations in the community and in families. On the other hand, more income may cause the concerned families to start to misbehave towards others in the community.

In *Idifu*, positive impacts of the rainwater harvesting measure "chololo pits" were assessed for the environmental dimension (+2.86), followed by the social (+2.79) and economic criteria (+2.28). *Soil fertility* and *water availability* were the highest positively assessed criteria. Negative assessment results were found for economic (−0.58) and environmental (−0.14) criteria, namely *yield*, *income*, *water availability* and *agrodiversity*. The reasons for the negative assessments were the time intensiveness and the workload necessary to set the pits up; therefore, less area can be prepared for cultivation. The possibility of drought can cause a high loss of investments.

The positive impacts for *fertilizer micro-dosing* were assessed on economic criteria (+2.82), followed by social (+2.81) and environmental (+2.67) criteria. The highest positive impacts were assessed on *income* and *agronomic education*. The reasons are the expectations of high yields and, therefore, increased income. Negative impacts were assessed in regards to environmental (−0.47) and social (−0.23) issues (*food diversity*, *social relations*, *agronomic knowledge*, *soil fertility*, *water availability and agrodiversity*). The reasons for negative assessments were the very contradictory opinions regarding fertilizer in the village, which could cause conflicts, the possibilities of harming health when inappropriately used, the dependence on fertilizer and, in drought years, harm to the plants.

In *Ilolo*, the farmers assessed positive impacts for "chololo pits" mainly on the environmental dimension (+2.74) but also on the social (+2.48) and economic dimensions (+2.28). The highest positively assessed impact was on *water availability*. Negative impacts were given for the economic (−0.77) and social dimensions (−0.58), namely on *yield*, *income*, *social relations*, and *working conditions*. The reasons behind the assessments were as follows: inefficiency and doubts regarding the preparation of agricultural plots of the same size as usual; that the setup of "chololo pits" is time, labour and money intensive; that conflicts may occur in families that are responsible for extra work; and jealousy in the village among those who benefitted and those who did not. For *fertilizer micro-dosing*, the positive assessments were rated highest for social aspects (+2.21), followed by economic (+1.95) and environmental issues (+1.74), with the highest ratings for *agrodiversity* and *working conditions*. Negative economic (−1.23), social (−0.92) and environmental (−0.62) impacts were assessed, mainly on *yield*, *income*, *market participation*, *food diversity*, *social relations*, *working conditions*, and *water availability*. The major concerns were a negative long-term effect on the soil fertility, the negative effects on production during drought years, the increased workload, and jealousy among farmers because of higher yields.

3.2.2. Assessment results for the food value chain component: processing/energy supply

In *Ilakala*, the farmers chose *by-products for bioenergy*, *improved processing devices* and, specifically here, a processing machine for maize threshing. The positive impacts for *by-products for bioenergy* were ranked the same for social (+2.56) and environmental criteria (+2.56), followed by economic criteria (+2.25). The two highest positive assessment results were for *agrodiversity* and *social relations*. Negative assessments were analysed for all three sustainability dimensions (environmental [−0.39], economic [−0.25], social [−0.06]), for the criteria *yield*, *working conditions*, *soil fertility*, *water availability*, and *agrodiversity*. The main concerns were an improper use of residues and that the application of the measure is work and time consuming, causing an increased workload.

For the *improved processing device* "maize thresher", the economic impact (+2.83) was the highest positively assessed, followed by the social (+2.58) and environmental impacts (+2.39). The two highest positively assessed criteria were *market participation* and *social relations*. Risks were assessed in regards to the economic (−0.42), social (−0.42) and environmental dimensions (+2.39) on the following criteria: *yield*, *income*, *market participation*, *social relations*, *working conditions*, *agronomic knowledge* and *agrodiversity*. The reasons for negative assessments were the misuse of higher income, the disrespect of others who do not have the same income, doubts regarding the maintenance and reparation costs of the machine, the possibility that the locality of the machine may be disadvantageous for those who live far from it, and the loss of traditional knowledge of threshing/deshelling.

In *Changarawe*, the positive impacts of the improved processing device maize thresher were assessed highest in regards to social criteria (+2.34), followed by economic (+2.28) and environmental criteria (+0.82). The maize thresher will simplify work and will therefore motivate farmers to produce more. Only one negative impact on *social relations* was assessed. Threshing is normally the responsibility of the women; if a man will refuse to let women use the machine, there will be familial conflicts. The positive assessments for *improved stove* were highest for the social dimension (+0.65), followed by the economic (+0.31) and environmental (+0.03) dimensions. The highest positive impacts were assessed on *working conditions*, *social relations* and *income*. Less time is needed for firewood collection, leading to faster cooking and more time available for family. Not one negative impact was assessed.

In *Idifu*, for the *improved processing device* millet thresher, we assessed positive economic (+2.48), social (+2.32) and environmental impacts (+1.21). The given reasons were simplified work, time saving and better quality of the processed product. The negative impacts were assessed on social (−0.39) and environmental criteria (−0.09), as follows: *social relations*, *working conditions*, *agronomic knowledge* and *agrodiversity*. The reasons given were jealousy of non-beneficiaries of the intervention, the loss of traditional knowledge on threshing, and the increased production of crops that can be processed in the machine. For the *improved processing device*, there were no significant assessment differences. For *improved stove*, the positive assessments were given for social (+1.83), economic (+1.33) and environmental (+0.17) criteria, with the two highest assessed criteria being *social relations* and *income*. The reasons were faster cooking, cooking with different pots at one time, and more time available for the family and community. The only negative impact was assessed on *social relations* because of the possible conflicts between beneficiaries and non-beneficiaries of the intervention.

In *Ilolo*, the positive assessment for the *improved processing device*, as in Idifu for the millet thresher, were highest for the economic criteria (+2.67), followed by social (+2.50) and environmental criteria (+1.41). The two highest impacts were assessed on *yield* and *market participation*. Risks were assessed only for the economic dimension (−0.38) on the three criteria *yield*, *income* and *market participation*. The given reasons were as follows: maintenance of the machine is costly and a higher quantity of well-processed crop causes competition and a price decline. The positive assessments for *wood supply* were given for all three sustainability dimensions (social [+2.77], environmental [+2.43] and economic [+2.41]). The two highest positive assessment results were on *social relations* and *agronomic knowledge*. Environmental (−0.54), economic (−0.49) and social (−0.35) risks were identified for *yield*, *income*, *market participation*, *social relations*, *working conditions*, *soil fertility*, *water availability* and *agrodiversity*. The negative impacts on the natural resources were all related to the fact that an unsuitable type of tree may affect negatively the surrounding crop production; an amount of firewood that is too high causes a price decline and potential conflict between livestock keepers and farmers.

3.2.3. Assessment results for the food value chain component: markets

In *Ilakala*, the workshop participants chose *optimized market orientated grain storage* as the priority UPS for implementation. Positive economic (+2.82), social (+2.62) and environmental (+1.91) impacts were assessed by the farmers. The highest positive assessed impacts were on *income*, *yield* and *agronomic knowledge*. Negative impacts were assessed in economic (−0.12) and social (−0.02) terms, for *market participation* and *social relations*, *respectively*. The reasons behind the negative assessments were high investments, the lack of knowledge on market development and jealousy between beneficiaries and non-beneficiaries of the measure.

In *Changarawe*, the farmers chose *poultry-crop integration* for their priority UPS. The farmers rated positive social (+2.70), economic (+2.63) and environmental (+2.40) impacts. The four highest positive impacts were assessed on *agronomic knowledge*, *yield*, *income* and *social relations*. Negative impacts were assessed in regards to social (−0.13), environmental (−0.13) and economic (−0.10) criteria, as follows: *income*, *market participation*, *social relations*, *working conditions*, *agronomic knowledge* and *water availability*. The reasons for negative assessments were high investment costs, the high risk of chicken diseases, competition in the market due to the fast growing chicken species, time consuming nature and need for continuous training.

The farmers in *Idifu* chose *new product development*, which is the pressing of sunflower oil in this case, for the UPS. The highest positive impact was assessed on economic criteria (+2.91), followed by social (+2.71) and environmental criteria (+2.03). The highest positive impacts were assumed for *yield*, *market participations* and *food diversity*. Negative social (−0.93), economic (−0.91) and environmental (−0.88) impacts were assessed on *yield*, *income*, *market participation*, *food diversity*, *social relations*, *working conditions*, *agronomic knowledge*, *soil fertility* and *agrodiversity*. The negative impacts are mainly related to the fact that increased sunflower oil production will also decrease the market price and, therefore, the income. Competition between the farmers may cause conflicts. In drought years, there will be no production.

In *Ilolo*, as in Idifu, the farmers chose sunflower oil production. The highest positive impacts were assessed on the economic dimension (+2.89) [social dimension: +2.69; environmental dimension: +1.06], and the highest assessed criteria were *income* and *agronomic knowledge*. Risks were assessed only for the economic criteria (−0.33) on *yield*, *income*, and *market participation*. The negative impacts are also related to drought years, yield failure, price loss because of increased production, and higher competition in the village.

3.2.4. Assessment results for the food value chain component: consumption

In all villages, the priority UPS was *household nutrition education*.

In *Ilakala*, positive impacts were assessed for all sustainability dimensions (social: +2.78; environmental: +2.50 and economic +2.30). The two highest assessed impacts were on *agrodiversity* and *agronomic knowledge*. The only negative impact was assessed on *market participation*.

During the positive assessment round in *Changarawe*, the highest impacts were assessed on the economic (+2.88) and social (+2.86) dimensions. The highest positive impacts were assessed for the two criteria *agrodiversity* and *market participation*. There were no negative impacts assessed on any of the criteria.

In *Idifu*, the highest positive assessment was on social criteria (+2.73) (economic: +2.37; environmental: +1.85); the highest positively assessed criteria were *food diversity* and *agronomic knowledge*. Environmental (−0.33), economic (−0.26) and social (−0.25) risks were identified, particularly on *income*, *market participation*, *social relations*, and *soil fertility*. Farmers explained that those farmers who benefitted from the education would earn much more income than would non-beneficiaries. Additionally, jealousy, vegetable theft, and a decreasing market price because of higher competition were given as risks.

In *Ilolo*, the highest positive impact was also assessed in regards to social criteria (+2.80) (economic: +2.58; environmental: 1.70). Negative impacts were assessed on the social (−0.14) and economic dimensions (−0.09), particularly on *market participation*, *food diversity* and *social relations* here. The reasons were jealousy, conflicts between beneficiaries and non-beneficiaries, decreases in price and income with too much competition in the village, and conflict at home regarding how to spend the surplus money. *Working conditions* were assessed more positively by women (+3.0) than by men (+2.5) because of the new agronomic knowledge, which will facilitate the horticultural production.

3.3. Assessment differences between the regions and between the villages within one region

3.3.1. Assessment differences on a regional level

In the first step, we analysed the significant assessment differences in regards to the impacts on the criteria for the same UPS between the two regions. In the following step, we compared the impact assessment differences on the food security criteria for the UPS *rainwater harvesting*, *fertilizer micro-dosing* (here, we compared the results from Ilakala in Dodoma with the results from the two villages in Morogoro) and *nutrition education*. When comparing the assessment results for the *rainwater harvesting* measures, significant assessment differences between Morogoro (Ilakala/Changarawe) and Dodoma (Ilolo/Idifu) were identified in regards to the impacts on the following criteria: *yield* ($\alpha = 0.01$), *income* ($\alpha = 0.02$), *market participation* ($\alpha = 0.04$), and *food diversity* ($\alpha = 0.01$) during the positive assessment round; and *market participation* ($\alpha = 0.00$) during the negative assessment round. When comparing the assessment results for *fertilizer micro-dosing* between Ilakala and the two villages Ilolo and Idifu, we found significant assessment differences for *market participation* ($\alpha = 0.04$), *food diversity* ($\alpha = 0.3$), and *water availability* ($\alpha = 0.005$) during the positive assessment round and for *income* ($\alpha = 0.03$) and *food diversity* ($\alpha = 0.04$) during the negative assessment round. Additionally, we assessed the significant assessment differences for the UPS *nutrition education*. Here, we analysed significant impact assessment differences between Morogoro (Ilakala/Changarawe) and Dodoma (Ilolo/Idifu) in regards to *yield* ($\alpha = 0.03$) during the positive assessment round and *social relations* ($\alpha = 0.03$) during the negative assessment round.

3.3.2. Assessment differences between the villages in each region

By comparing the assessment results for *rainwater harvesting* between the two villages Ilakala and Changarawe in Morogoro, we found significant differences only for *yield*, *income*, and *market participation* for the negative assessments. For *improved processing device*, significant differences were found for *yield*, *market participation*, *soil fertility*, *water availability*, and *agrodiversity* during the positive assessment round and for the criteria *social relations* during the negative assessment round (See Table 5). For *household nutrition education*, significant differences for the positive assessments were found for the criteria *market participation*, *soil fertility*, and *water availability*.

Upon comparing the two villages Ilolo and Idifu in Dodoma, significant assessment differences for positive impact (Table 4) were found for *rainwater harvesting* in regards to *income* and *working conditions* during the positive assessment round. During the negative assessment round, significant differences were found for *income*, *social relations* and *working conditions*. For *fertilizer micro-dosing*, significant assessment differences for positive impacts were found for *income*, *market participation*, *food diversity*, *agronomic knowledge* and *water availability* and during the negative assessment round for *yield*, *income*, *market participation*, *food diversity*, *social relations*, *working conditions*, *agronomic education*, *soil fertility*, *water availability*, *and agrodiversity*. In regards to *new product development* ("sunflower oil"), the impact on *water availability* was assessed significantly differently in the two villages during the positive round (Table 6). In regards to the negative impacts, significant differences were found for *market participation*, *food diversity*, *social relations*, *working conditions*, *agronomic knowledge*, *soil fertility* and *agrodiversity*. The significant assessment differences in regards to nutrition were limited to *income* and *soil fertility* during the negative assessment round. (See Table 7.)

4. Discussion

4.1. Key findings

During the assessments of all UPS, the positive impacts were dominant. The positive impacts of the UPS in the food value chain component *NRM/food production* were mainly attributed to increased agricultural production and its related positive impacts such as increased income and, therefore, the access to necessary means to diversify the diet. In the "Comprehensive Food Security and Vulnerability Analysis Tanzania 2012" (WFP, 2013), agricultural productivity was also emphasized as a major challenge for smallholder food insecurity. Stakeholders also mentioned the uncertainty und risks such as the possibility of drought years and the increased workload and time intensiveness for all UPS in this food value chain component. Women viewed the increased workload more critically than did men. This supports the observation that women in Sub-Saharan Africa have high overall labour-force participation rates. In fact, 60–80% of the agricultural labour conducted in this sector is performed by women (Ezezika et al., 2013; FAO, 2011; Croppenstedt et al., 2013), and women are more concerned by a potential increase in the labour force. Particularly, *fertilizer micro-dosing* was controversially discussed among farmers. The farmers mentioned that fertilizer may have negative long-term effects on the soil. In fact, fertilizers that are not properly used, are overused, are wrongly placed on a plant part or are placed while soil moisture is inadequate may harm the plant and pollute the environment (Sanginga and Woomer, 2009). Chianu et al. (2012) highlight the need for farmers' training and knowledge sharing in regards to fertilizer use. Benson et al. (2013) also highlight that inorganic fertilizer use for farmers in Tanzania is challenging because it is costly, there is a lack of information on proper use, there is the risk of crop failure because of the lack of rainfall, and it is less costly to cultivate new arable land. During the impact assessment workshops, we observed that there is a high need for training and sensitization to fertilizer use not only in the sense of proper use but also in regards to the realistic advantages and risks of fertilizer use. In regards to *processing/energy supply UPS*, risks and doubts were identified related to costs of the maintenance of machines, and worries regarding loose traditional practises such as manual threshing were mentioned. The better quality of products and the simplified and less time intensive work processes were mentioned positively by farmers. For marketing-related UPS, the income was indicated to increase, but in all case study villages, the farmers also mentioned the possible negative impact on market participation caused by increased production and, therefore, higher competition and possible client loss. A cross-cutting concern that was mentioned in all localities was the high potential for social conflicts. Social conflicts were attributed to jealousy between non-beneficiary and beneficiaries. Therefore, the access of all villagers to knowledge and technology must be guaranteed to decrease potential conflicts at the case study sites. Scientists involved in the process must take these new findings into account during the implementation of UPS. Mayoux and Chambers (2005) and Kristjanson et al.

Table 4
Natural resource management and food production impact assessment results and significant assessment differences on food security criteria.

	Ilakala								Changarawe							
	Rainwater harvesting				Fertilizer micro-dosing				Rainwater harvesting				Optimized weeding			
Criteria	(+)	Std	(−)	Std	(+)	Std	(−)	Std	(+)	Std	(−)	Std	(+)	Std	(−)	Std
Yield	3.00	0.00	***0.00	0.00	3.00	0.00	0.00	0.00	2.55	0.93	***1.36	1.03	2.91	0.30	0.00	0.00
Income	3.00	0.00	*0.00	0.00	3.00	0.00	0.00	0.00	2.64	0.92	*1.45	1.51	3.00	0.00	0.27	0.91
Market participation	2.78	0.44	***0.00	0.00	3.00	0.00	0.00	0.00	2.82	0.60	***1.36	1.03	2.55	0.82	0.27	0.91
Food diversity	3.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	2.73	0.91	0.00	0.00
Social relations	2.89	0.33	0.00	0.00	3.00	0.00	0.00	0.00	2.73	0.47	0.36	0.81	3.00	0.00	0.27	0.91
Working conditions	2.89	0.33	1.22	1.30	2.67	1.00	0.67	1.32	2.82	0.41	1.00	0.63	1.55	1.51	0.00	0.00
Agronomic knowledge	2.89	0.33	0.00	0.00	3.00	0.00	0.00	0.00	3.00	0.00	0.18	0.60	3.00	0.00	0.00	0.00
Soil fertility	2.89	0.33	0.00	0.00	3.00	0.00	0.00	0.00	2.73	0.91	0.55	1.21	2.91	0.30	0.00	0.00
Water availability	3.00	0.00	0.00	0.00	2.89	0.33	0.33	1.00	3.00	0.00	0.55	1.21	3.00	0.00	0.00	0.00
Agrodiversity	2,78	0.44	0.00	0.00	2.89	0.33	0.00	0.00	3.00	0.00	0.09	0.30	3.00	0.00	0.00	0.00

*Criteria with a significant difference (α ≤ 0.05), **Criteria with a significant difference (α ≤ 0.01), ***Criteria with a significant difference (α ≤ 0.001).

	Ilolo								Idifu							
	Rainwater harvesting				Fertilizer micro-dosing				Rainwater harvesting				Fertilizer micro-dosing			
Criteria	(+)	Std	(−)	Std	(+)	Std	(−)	Std	(+)	Std	(−)	Std	(+)	Std	(−)	Std
Yield	2.31	0.86	0.85	0.80	2.31	1.18	**1.15	1.52	1.83	1.19	1.50	1.57	2.83	0.39	**0.00	0.00
Income	**2.15	0.56	**1.46	1.13	*2.08	1.32	***1.54	1.20	**2.83	0.58	**0.25	0.87	*3.00	0.00	***0.00	0.00
Market participation	2.38	0.65	0.00	0.00	*1.46	1.51	**1.00	1.35	2.17	1.27	0.00	0.00	*2.67	0.89	**0.00	0.00
Food diversity	2.46	0.78	0.00	0.00	*1.69	1.32	**1.38	1.39	2.83	0.39	0.00	0.00	*2.67	0.89	**0.08	0.29
Social relations	2.38	0.87	*0.85	1.21	1.85	1.35	*1.23	1.48	2.75	0.87	*0.00	0.00	2.75	0.62	*0.08	0.29
Working conditions	*2.31	0.75	***1.46	0.88	2.69	0.48	**1.08	1.38	*2.83	0.58	***0.00	0.00	2.83	0.58	**0.00	0.00
Agronomic knowledge	2.77	0.44	0.00	0.00	*2.62	0.65	**0.00	0.00	2.75	0.87	0.00	0.00	*3.00	0.00	**0.75	0.87
Soil fertility	2.85	0.38	0.00	0.00	2.54	1.13	*0.00	0.00	2.92	0.29	0.00	0.00	2.75	0.87	*0.50	0.91
Water availability	3.00	0.00	0.00	0.00	***0.00	0.00	**1.85	1.35	2.92	0.29	0.08	0.29	***2.5	1.17	**0.17	0.39
Agrodiversity	2.38	1.12	0.00	0.00	2.69	0.75	**0.00	0.00	2.75	0.62	0.33	0.89	2.75	0.87	**0.75	0.97

*Criteria with a significant difference (α ≤ 0.05), **Criteria with a significant difference (α ≤ 0.01), ***Criteria with a significant difference (α ≤ 0.001).

(2002)highlighted the advantage of local stakeholders to identify interlinkages that are invisible to external observers. Reed (2008) argued that interlinking local knowledge and scientific knowledge provides a more comprehensive understanding of complex and dynamic systems and processes and will produce more relevant and effective practises. As stated by Millstone et al. (2010), farmers have valuable knowledge on the characteristics and dynamics of the farmers' own ecological and socioeconomic environments. The

Table 5
Post harvesting processing and biomass/energy supply impact assessment results and significant assessment differences on food security criteria.

	Ilakala								Changarawe							
	Improved processing device				By-products for bioenergy				Improved processing device				Improved stove			
Criteria	(+)	Std	(−)	Std	(+)	Std	(−)	Std	(+)	Std	(−)	Std	(+)	Std	(−)	Std
Yield	*2.92	0.29	0.42	0.79	2.33	0.78	0.75	1.13	*2.54	0.52	0.00	0.00	0.31	0.75	0.00	0.00
Income	2.58	0.52	0.42	1.00	2.42	0.52	0.00	0.00	2.23	0.83	0.00	0.00	0.38	0.96	0.00	0.00
Market participation	**3.00	0.00	0.42	1.00	2.00	1.04	0.00	0.00	**2.08	1.04	0.00	0.00	0.23	0.83	0.00	0.00
Food diversity	2.00	1.13	0.25	0.87	2.58	0.52	0.00	0.00	2.38	1.12	0.00	0.00	0.15	0.56	0.00	0.00
Social relations	2.58	1.00	*0.42	0.90	2.75	0.62	0.00	0.00	1.85	1.41	*0.38	0.96	0.38	0.96	0.00	0.00
Working conditions	3.00	0.00	0.50	1.00	2.33	0.78	0.25	0.43	2.85	0.38	0.00	0.00	2.00	1.08	0.00	0.00
Agronomic knowledge	2.75	0.62	0.50	1.17	2.58	0.67	0.00	0.00	2.31	0.95	0.00	0.00	0.08	0.28	0.00	0.00
Soil fertility	*2.25	1.22	0.00	0.00	2.42	0.67	0.67	0.65	*0.92	1.12	0.00	0.00	0.00	0.00	0.00	0.00
Water availability	***2.33	1.23	0.00	0.00	2.50	0.80	0.25	0.62	***0.46	1.13	0.00	0.00	0.00	0.00	0.00	0.00
Agrodiversity	*2.58	0.90	0.33	0.89	2.75	0.62	0.25	0.87	*1.08	1.38	0.00	0.00	0.08	0.28	0.00	0.00

*Criteria with a significant difference (α ≤ 0.05), **Criteria with a significant difference (α ≤ 0.01), ***Criteria with a significant difference (α ≤ 0.001).

	Ilolo								Idifu							
	Improved processing device				Wood supply				Improved processing device				Improved stoves			
Criteria	(+)	Std	(−)	Std	(+)	Std	(−)	Std	(+)	Std	(−)	Std	(+)	Std	(−)	Std
Yield	2.77	0.60	0.31	0.63	1.85	1.41	0.23	0.60	2.36	0.92	0.00	0.00	1.40	1.43	0.00	0.00
Income	2.46	0.88	0.38	0.77	2.69	0.48	0.23	0.60	2.45	1.04	0.00	0.00	2.30	1.16	0.00	0.00
Market participation	2.77	0.60	0.46	0.97	2.69	0.86	1.00	1.29	2.64	0.92	0.00	0.00	0.30	0.95	0.00	0.00
Food diversity	2.46	0.88	0.00	0.00	2.62	0.96	0.00	0.00	2.00	1.41	0.00	0.00	2.00	1.41	0.00	0.00
Social relations	2.23	1.17	*0.00	0.00	3.00	0.00	0.92	1.32	2.45	1.04	*0.55	1.04	2.60	0.97	0.50	1.08
Working conditions	2.62	0.77	0.00	0.00	2.62	0.77	0.46	1.13	2.73	0.65	0.45	1.04	2.20	1.23	0.00	0.00
Agronomic knowledge	2.69	0.86	0.00	0.00	2.85	0.38	0.00	0.00	2.09	1.14	0.55	1.21	0.50	1.08	0.00	0.00
Soil fertility	1.31	1.44	0,00	0.00	2.38	0.96	0.69	1.32	1.09	1.51	0.00	0.00	0.00	0.00	0.00	0.00
Water availability	*1.08	1.32	0.00	0.00	2.54	1.13	0.54	0.97	*0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agrodiversity	1.85	1.35	0.00	0.00	2.38	1.12	0.38	0.87	2.55	1.04	0.27	0.91	0.50	1.08	0.00	0.00

*Significant differences for *improved processing device* between Ilolo and Idifu.

Table 6
Marketing impact assessment results and significant assessment differences on food security criteria.

	Ilakala				Changarawe				Ilolo				Idifu			
	Grain storage				Poultry-crop integration				New product development				New product development			
Criteria	(+)	Std	(−)	Std	(+)	Std	(−)	Std	(+)	Std	(−)	Std	(+)	Std	(−)	Std
Yield	2.82	0.41	0.00	0.00	2.80	0.42	0.00	0.00	2.83	0.39	0.33	0.78	3.00	0.00	0.64	0.67
Income	3.00	0.00	0.00	0.00	2.80	0.42	0.10	0.32	3.00	0.00	0.33	0.78	2.73	0.47	0.82	0.87
Market participation	2.64	0.67	0.36	0.81	2.30	0.82	0.20	0.63	2.83	0.39	*0.33	0.78	3.00	0.00	*1.27	1.27
Food diversity	2.64	0.51	0.00	0.00	2.40	0.84	0.00	0.00	2.83	0.58	**0.00	0.00	3.00	0.00	**1.18	1.25
Social relations	2.73	0.65	0.09	0.30	2.80	0.42	0.10	0.32	2.50	0.67	**0.00	0.00	2.73	0.65	**1.27	1.27
Working conditions	2.27	1.27	0.00	0.00	2.60	0.70	0.30	0.48	2.50	0.67	*0.00	0.00	2.36	0.92	*0.64	0.81
Agronomic knowledge	2.82	0.60	0.00	0.00	3.00	0.00	0.10	0.32	2.92	0.29	*0.00	0.00	2.73	0.65	*0.64	0.81
Soil fertility	1.55	1.44	0.00	0.00	2.70	0.48	0.00	0.00	2.17	1.03	***0.00	0.00	2.27	1.01	***1.09	0.94
Water availability	1.73	1.49	0.00	0.00	1.80	1.32	0.10	0.32	***0.00	0.00	0.00	0.00	***2.36	0.92	0.00	0.00
Agrodiversity	2.45	1.21	0.00	0.00	2.70	0.68	0.30	0.95	1.00	0.85	***0.00	0.00	1.45	1.21	***1.55	1.37

*Criteria with a significant difference (α ≤ 0.05), **Criteria with a significant difference (α ≤ 0.01), ***Criteria with a significant difference (α ≤ 0.001).

farmers "foresee [...] problems that [are] outside the researchers' frame of reference".

4.2. Food security and sustainability

Sustainable agricultural development and food security are strongly interlinked, particularly in small-scale farming (WSSD, 2002; FAO, 2013). In this study, we began with a local definition of food security. The 10 criteria, which describe food security from the farmers' point of view, present the multi-dimensionality of food security in the local context. Food security involves much more than increased food production (McKenzie and Williams, 2015). The criteria that constitute food security in the four villages correspond to three sustainability dimensions: the environment, the economy and social life. Clustering the 10 criteria according to the sustainability dimensions shows that to achieve food security, a healthy equilibrium must be established among the three dimensions (Helming et al., 2011). Several authors argue that environmental sustainability constitutes the entry point for agricultural development and for food security (Garnett et al., 2013; McKenzie and Williams, 2015). We found that smallholder agri-food systems and local food security are strongly dependent on socio-economic and environmental criteria and their interdependence, as was also highlighted by Zimmerer et al. (2015). The three dimensions must be simultaneously considered to achieve food security, particularly in small-scale farming.

4.3. UPS selection and potential trade-offs

The adapted FoPIA enabled the quick and transparent identification of trade-offs between the chosen UPS and priority food security criteria at the four case study sites (König et al., 2012, 2013; Schindler et al., 2015). The rating on food security criteria showed that the priority to achieve food security lies on environmental criteria in most villages and on economic improvement only in Changarawe. From the eight UPS chosen in the field of *crop production/NRM*, four have the highest impact on environmental criteria, three on economic criteria, and one on social criteria. The UPS in the field of *processing/energy supply* have the highest impact on the social dimension (five out of eight UPS). In regards to the four *markets* UPS, three UPS have the highest positive impacts on the economy, while *nutrition education* (consumption UPS) has the highest impacts on social criteria in three of the four villages.

We also assessed how the chosen UPS correspond with the highest ranked criterion for food security for each village. The farmers in Ilakala rated *water availability* as the priority criterion to improve food security. Nevertheless, the farmers chose two UPS, *by-products for bioenergy* and *fertilizer micro-dosing*, for which they assessed possible negative impacts on *water availability*. The farmers in Changarawe rated *agronomic knowledge* as most important to improve food security. However, when the farmers chose UPS, they picked two, having negative impacts on *agronomic knowledge*: *rainwater harvesting* and *poultry crop integration*. The highest ranked food security criterion in Ilolo was *working conditions*. However, when the farmers chose UPS, they chose *rainwater harvesting* "chololo pits", *fertilizer micro-dosing* and *wood supply*, which were assessed to have negative impacts on this particular criterion. In Idifu, *market participation* was the highest ranked criterion for enhanced food security. However, considering the discussion by the farmers, *new product development* ("sunflower oil production") and *nutrition education* have high potential to have negative impacts on *market participation*. This shows, as argued by Morris et al. (2011), that trade-offs are unavoidable. Considering the trades-offs between environmental, economic and social issues is key and must inform the stakeholders to find compromises. (Tittonell et al., 2007) argues that smallholder

Table 7
Consumption impact assessment results and significant assessment differences on food security criteria.

	Ilakala				Changarawe				Ilolo				Idifu			
	Nutrition education				Nutrition education				Nutrition education				Nutrition education			
Criteria	(+)	Std	(−)	Std	(+)	Std	(−)	Std	(+)	Std	(−)	Std	(+)	Std	(−)	Std
Yield	2.70	0.95	0.00	0.00	2.91	0.30	0.00	0.00	2.36	1.03	0.00	0.00	2.22	1.09	0.00	0.00
Income	2.80	0.63	0.00	0.00	2.73	0.65	0.00	0.00	2.55	1.04	*0.00	0.00	2.44	0.73	*0.67	1.12
Market participation	**1.40	1.51	0.10	0.32	**3.00	0.00	0.00	0.00	2.82	0.41	0.27	0.91	2.44	0.53	0.11	0.33
Food diversity	2.80	0.63	0.00	0.00	2.91	0.30	0.00	0.00	2.64	0.92	0.45	1.04	2.89	0.33	0.00	0.00
Social relations	2.80	0.42	0.00	0.00	2.91	0 .30	0.00	0.00	2.73	0.91	0.09	0.30	2.56	0.73	1.00	1.50
Working conditions	2.50	1.08	0.00	0.00	2.91	0.30	0.00	0.00	2.82	0.41	0.00	0.00	2.56	0.73	0.00	0.00
Agronomic knowledge	3.00	0.00	0.00	0.00	2.71	0.91	0.00	0.00	3.00	0.00	0.00	0.00	2.89	0.33	0.00	0.00
Soil fertility	***2.40	1.27	0.00	0.00	***0.00	0.00	0.00	0.00	0.82	1.40	*0.00	0.00	0.56	1.13	*1.00	1.50
Water availability	***2.10	1.45	0.00	0.00	***0.00	0.00	0.00	0.00	1.27	1.49	0.00	0.00	2.22	1.30	0.00	0.00
Agrodiversity	3.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	2.78	0.67	0.00	0.00

*Significant differences for *nutrition education* between Ilakala and Changarawe and between Ilolo and Idifu.
*Criteria with a significant difference (α ≤ 0.05), **Criteria with a significant difference (α ≤ 0.01), ***Criteria with a significant difference (α ≤ 0.001).

farmers in Sub-Saharan Africa face multiple trade-offs when deciding on the allocation of their available resources. They emphasize that understanding of the trade-offs is even a basic premise for addressing farm-scale questions such as the efficient use of available resources. The discovery of trade-offs can thus be described as a co-learning process (Giller et al., 2011).

4.4. Participatory impact assessment

Using the participatory approach, the farmers defined their local food security situation, developed the relevant food security criteria in their food context and analysed the advantages and risks of the given UPS in a participatory manner. The need for stakeholder involvement in impact assessment processes to understand the context, identify bottlenecks and adapt measures to the local environment is highlighted by several authors (König et al., 2012, 2013; Mayoux and Chambers, 2005; Mayoux and Mosedale, 2005). As stated by Millstone et al. (2010): "[…] researchers often embark on their projects by taking their theories of change for granted; there is a strong case for actively inviting the likely participants in the innovation". Application of the FoPIA allowed an individual assessment process. The farmers, both women and men, reflected their individual point of view on the positive and negative impacts of the proposed UPS to enhance their food security situation. The secret individual assessment allowed integration of the views of all affected parties, which is an important prerequisite for sustainability impact assessment (Gibson et al., 2005; Gibson, 2006; Bond et al., 2012). In a joint evaluation round, the participants presented their point of view in public, or the researcher approached the farmers after the workshop for an individual interview following the process. The group discussion facilitated an exchange and learning process, as described by the farmers themselves in a concluding workshop. Particularly in the sense of sustainability impact assessment, different authors highlight the need for "embedded learning" due to stakeholder involvement (Schindler et al., 2015; Gibson, 2006; Bond et al., 2012; Bond and Morrison-Saunders, 2013; Becker et al., 2003).

However, we also observed challenges with the methodological approach, which were partly also provided as feedback by the workshop participants. The duration of the impact assessment process was long and was perceived by some of the participants as tiring. A pre-test showed that the simultaneous deliberative assessment on a scale ranging from negative to positive was too complicated at the local level. Therefore, positive and negative assessment rounds were performed separately, which was very time consuming.

As already mentioned above, in all assessments, the positive impacts were dominant over the negative impacts. One reason may be that the UPS was already prioritized among others for the particular food value chain component. Additionally, the presence of researchers during the assessment workshops may have caused the farmers to be hesitant and intimidated to freely state their doubts (Jakobsen, 2012). It is very challenging for the moderators and accompanying researchers to build on grassroots learning in the assessment process without dominating the process for their own needs (Mayoux et al., 2005). A successful impact assessment requires an empathetic moderator who knows the local context and language (Becker et al., 2003). Reed (2008) argued that the outcome of any participatory process more strongly depends on the moderation than on the tools used. During our fieldwork, we observed that the workshops went well if the moderator participated in lively discussion with the farmers, emphasizing the importance and relevance of their feedback, while the researchers stayed in the background, not interacting with the workshop participants. The use of grains to express an individual opinion has been shown to be useful during the assessment process. Nevertheless, for future application, it would be an interesting additional element to integrate drawing exercises for a more interactive process and to visualize impacts as already successfully practised by different researchers (Mayoux et al., 2005; Mayoux and Chambers, 2005; Alvarez et al., 2010; Douthwaite et al., 2007). We also observed that women very rarely spoke during the common evaluation and feedback rounds of the results. For future impact assessments, we recommend that the evaluation of assessment rounds be organized separately for male and female participants (Jakobsen, 2012; Kristjanson et al., 2002).

In the case presented, the adapted FoPIA was used for ex-ante impact assessment of planned UPS in order to discover assumed positive and negative impacts on food security criteria from the farmers perspective and to consequently adapt these measures before implementation to avoid their failure (Ridder and Pahl-Wostl, 2005). This adapted framework may also be applied for participatory monitoring and evaluation (ex-post). In case the framework is further used for ex-post impact assessment of the UPS in the same locality, we recommend first revisiting the food security criteria with the community before starting the assessment process. This is critical for having a common understanding and, if necessary, to adapt the criteria because these might change over time and in a changing environment.

5. Conclusion

In the present study, we applied a participatory impact assessment framework (FoPIA) with small-scale farmers at four different case study villages in rural Tanzania. The farmers identified positive and negative sustainability impacts on locally relevant food security criteria and several interlinkages of intended UPS, their socio-economic life and the environment. The adapted FoPIA enabled also a quick and transparent identification of trade-offs between the chosen UPS and priority food security criteria at the four case study sites. The results of the sustainability impact assessment are valuable to adapt intended development interventions to the locality and to decrease the assessed potential negative impacts. Impact assessment results from one locality cannot simply be transferred to another locality, even if the distance between the case study sites is very limited, because each locality has its own characteristics and particularities. Active stakeholder involvement and embedded learning is an essential element of sustainability impact assessment. Only the interlinkage of local knowledge and scientific knowledge provides a more comprehensive understanding of complex and dynamic systems and processes and will produce more relevant and effective practises. While we used the framework for ex-ante impact assessment, it may also be applied for monitoring and evaluation.

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4.3 3rd Paper: Participatory impact assessment: Bridging the gap between scientists' theory and farmers' practice

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Participatory impact assessment: Bridging the gap between scientists' theory and farmers' practice

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ABSTRACT

Food security is a major challenge for smallholders in Sub-Saharan Africa. Many development initiatives have attempted to enhance food security by improving agricultural production and productivity. An ex-ante impact assessment is a critical step for identifying positive and negative impacts before implementation of these agricultural innovations and it is therefore a critical component during project-/program planning. While many theoretical discourses have highlighted a strong need for active involvement of local stakeholders during project-/program planning to develop suitable solutions, in practice, local communities are still not mandatorily involved in the ex-ante impact assessment before the implementation of development initiatives. The purpose of this research is to highlight how stakeholders' and researchers' knowledge can enhance the quality of impact assessments if they are used in a complementary way. We applied two methodological impact assessment approaches (Framework for participatory impact assessment [FoPIA] and ScalA-Food Security [ScalA-FS]) to assess the impacts of five agricultural upgrading strategies (UPS) from a researcher's perspective as well as from a farmer's point of view in two case study villages in rural Dodoma, Tanzania. We observed that farmers and scientists had considerably different views on the impacts of the proposed agricultural UPS. While scientists focused on direct causal impact chains of the UPS, farmers considered more the indirect linkages, taking into account their complex livelihoods. Ex-ante impact assessment is a valuable tool to anticipate possible effects, and the process facilitates insights into complex socio-environmental contexts of local communities as well as structured thinking and knowledge exchange. We therefore see bi-lateral ex-ante impact assessments as a corrective step before UPS implementation, which would help to adapt solutions that will benefit local communities.

1. Introduction

Approximately 805 million people in the world were estimated to be chronically undernourished in 2014; this is particularly the case in the sub-Saharan region, where more than one in four people are undernourished (FAO, 2014). Although smallholders grow the majority of agricultural produce, they are the poorest and most hungry population group in developing countries in this region (IAASTD, 2009; Dethier and Effenberger, 2012; IFAD and UNEP, 2013). Several development initiatives have attempted to enhance food security by improving agricultural production and productivity of smallholder farmers. These initiatives all presuppose some theory of change (Millstone et al., 2010), implying that the implementation of new or modified agricultural practices, would improve the lives of the intended beneficiaries. Millstone et al. (2010) and Ridder and Pahl-Wostl (2005) emphasize that there is a strong need for actively inviting the likely beneficiaries to comment on the researcher's intended interventions during the planning stage, before its implementation. Ex-ante impact assessment is a critical step during the project-/program planning phase for identifying positive and negative impacts before implementation of these agricultural interventions (Maredia, 2009). The IAIA (2009) defines impact assessment as "the process of identifying the future consequences of a current or proposed action. On one hand it is a "technical tool for analysis of the consequences of a planned intervention (policy, plan, program, project), providing information to stakeholders and decision-makers" and on the other it is "a legal and institutional procedure linked to the decision-making process of a planned intervention". With the help of an ex-ante impact assessment, negative side effects may be discovered that may help to adjust the intended measures to be more suitable in the local context (EIARD, 2003; Millstone et al., 2010).

Several researchers have highlighted in their theoretical discourses that the active involvement of local stakeholders throughout the impact assessment process is crucial (Bond et al., 2012; Bond and Morrison-Saunders, 2013; Gibson, 2006). Pro-poor development and improving practices of the smallholders requires the active involvement

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of the population targeted by the planned intervention (Mayoux and Chambers, 2005; Schindler et al., 2015; Ridder and Pahl-Wostl, 2005). By involving local stakeholders the quality and durability of collective decisions in planned interventions is likely to be greater (Reed, 2008).

The field of impact assessment lacks concrete case studies where the differences in perceptions between local farmers and researchers are analysed, showing the value of using local stakeholders' perceptions and scientific expert knowledge in an integrative way in order to enhance the quality and relevance of development initiatives. This is particularly needed in so-called developing countries, where local knowledge is crucial to understand the real needs of the community, in addition to more theoretical research project proposals that are often designed at a researcher's level without real stakeholder participation.

The purpose of this study is to highlight how stakeholders' and researchers' knowledge can enhance the quality of impact assessments if they are used in a complementary way.

We present the results of an ex-ante sustainability impact assessment of agricultural upgrading strategies (UPS) that were carried both out at the local farmer's level as well as separately with researchers. These UPS were developed within the framework of the research project Trans-SEC (http://project2.zalf.de/trans-sec/public/), which intends to implement best practices with high potential for enhancing food security in different case study villages in rural Tanzania.

Table 2
Food security criteria elaborated by smallholder farmers at the case study site.
(Adapted from Schindler et al., 2016b).

Criterion	Sustainability dimension	Definition and regional relevance
Food diversity	Social	Sufficient number of meals (= 3) per day offering a diversified and balanced diet
Social relations	Social	Community support during family need (i.e., drought, family incidences such as illness, death) and share of the workload (i.e., field ploughing), family support and understanding of decision-making about households resources
Working conditions	Social	Access to appropriate technology/equipment and agricultural practices, reducing working hours and workload
Yield	Economic	Amount of food produced and available for family consumption and for selling
Income	Economic	Family financial resources earned from agricultural production and off-farm activities
Market participation	Economic	Selling and buying agricultural products and other needs; knowledge of market prices for improved negotiation power of farmers towards buyers
Soil fertility	Environmental	Quality of the soil for agricultural production
Water availability	Environmental	Soil water availability for agricultural production
Agrodiversity	Environmental	Cultivation of crop variety for family consumption and for selling; risk management in case of crop failure

2. Methods

2.1. Methodological approaches

For the ex-ante impact assessment on the researchers' and farmers' levels, we used two different methodological approaches, ScalA-Food Security [ScalA-FS] (Uckert et al., 2016) and Framework for participatory impact assessment [FoPIA] (Morris et al., 2011; König et al., 2012; König et al., 2013; Schindler et al., 2016a; Schindler et al., 2016b). We adapted both approaches to our case study in rural Tanzania (Uckert et al., 2016; Schindler et al., 2016a; Schindler et al., 2016b). ScalA-FS is an ex-ante impact assessment tool to collect scientists' knowledge of possible UPS impacts; FoPIA was used to carry out a participatory ex-ante impact assessment with farmers of the same UPS (Table 1) in relation to the same set of food security criteria (Table 2). We chose these two ex-ante impact assessment tools after comparing different methodological approaches (Schindler et al., 2015) and found ScalA-FS and FoPIA optimal for our research with the two different target groups. The researchers of the Trans-SEC consortium are dispersed across Tanzania, Germany and the USA. In order to reach them we needed a tool that can be filled in digitally and is easily handled and adjusted to the UPS and the food security criteria which were relevant for our impact assessment. With the farmers we organized workshops in Dodoma. For the ex-ante impact assessment with the farmers we slightly adapted the original FoPIA (Morris et al., 2011), to fit our local farmer context. Here, we present the impact assessment results of a sample of five UPS, which were selected by the farmers as priority UPS to be implemented in their villages. All UPS were developed by researchers of the Trans-SEC consortium on the basis of a problem analysis with farmers in regards to agricultural production at the case study sites.

Table 1
Upgrading strategies.
(Adapted from Uckert et al., 2016).

Upgrading strategies
1. Rainwater harvesting (RWH): In-situ RWH using tied ridges in the sub-humid region and infiltration pits in the semi-arid region (Mahoo et al., 2012)
2. Fertilizer micro-dosing: Micro-dose rates of 5–6 kg P/ha (2–5 g/hill as NPK) placed 4–8 cm away and lateral to the seeds, with higher rates in more humid climates (Bagayoko et al., 2011)
3. Improved processing devices: Mobile maize shelling machines in the sub-humid region and millet winnowing machines in the semi-arid region, including a business plan for investment and pay-offs (Mejia, 2003)
4. New product development: Enhanced horizontal and vertical coordination of sunflower oil production, including investment in sunflower oil press (RLDC, 2008)
5. Household nutrition education: Increased awareness of nutrient-rich indigenous foods and making better use of their crops (Roy et al., 2005)

2.1.1. ScalA-Food Security (ScalA-FS)

For the impact assessment with researchers we adapted ScalA, which was developed in the framework of a preceding research project (www.sustainet.org) (Crewett et al., 2011) and modified it towards collecting and assessing impacts of UPS on food security criteria, hence being renamed ScalA-FS (Uckert et al., 2016). ScalA-FS aims to systematically evaluate agricultural practices prior to their implementation. Using ScalA-FS, we asked participating scientists to assess the social, economic and environmental impacts of the planned UPS in regards to the same food security criteria (Tables 1 & 2), just as we did with FoPIA at the community level. The ScalA-FS tool was filled in by 15 to 22 researchers of an international consortium involved in the Trans-SEC project for these five UPS (Uckert et al., 2016). Researchers filled in the ScalA-FS tool only for the particular UPS they had sufficient expertise. Therefore, the number of researchers and answers varied.

2.1.2. Framework for participatory impact assessment (FoPIA)

FoPIA provides a generic framework with a sequence of methods for conducting sustainability impact assessments in different regional contexts at the European level (Morris et al., 2011). It was adapted and tested by König et al. (2010) to be applicable to the context of land use changes in developing countries (König et al., 2012; Purushothaman et al., 2012; König et al., 2013). For this particular study, FoPIA was adapted by Schindler et al. (2016a); Schindler et al. (2016b) to be used for impact assessments at the community level with farmers. This modified FoPIA (Schindler et al., 2016b) comprises two main parts: 1) an analysis of the contexts of geography and food security, and 2) an ex-ante impact assessment of local food security UPS. Part 1) consists of two steps: A) the definition of the food security context, and B) the definition and analysis of food security criteria. Part 2) consists of three steps: A) the presentation and participatory selection of

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UPS, B) an UPS impact assessment, and C) a presentation of results and stakeholder feedback (Schindler et al., 2016b) (Fig. 1).

Here, we present the impact assessment results of two villages, Ilolo and Idifu, in the Dodoma Region. A group consisting of 22–25 farmers participated in each UPS impact assessment workshop.

For the impact assessment, we invited farmers to participate according to the following criteria: (I) their competence, experience and knowledge regarding the food value chain component and related UPS; (II) their knowledge on the agricultural practices in the village; (III) the representation of different sub-villages; (IV) a mixed representation of gender (approximately 50% women and 50% men); (V) a representation of different age groups (young: age 15–25 years, adults, elderly people: age ≥ 60 years); (VI) the economic status of the household (poor, moderate, better off); and (VII) stakeholder participants should not be too dominant due to their hierarchical position. According to these criteria, the impact assessment for each UPS was done with a different farmers group in order to obtain their specific experience/expertise with a particular UPS. The selection of the participants corresponding to the criteria above was done with the help of local authorities and local agricultural advisors in each village.

To make the assessments from FoPIA and ScalA-FS comparable, we implemented the same set of food security criteria (Schindler et al., 2016b) and the same scoring approach (Morris et al., 2011). The farmers and the scientists were asked the same main question; they were requested to assess the impacts of five UPS (Table 1) for a set of food security criteria (Table 2) on a scale from −3 (high negative impact) to +3 (high positive impact) [0 = no impact, neither positive nor negative].

2.2. Data analysis

The data generated during the application of FoPIA and ScalA-FS were analysed with IBM SPSS Statistics 22. We analysed the arithmetic average, minimum and maximum scoring values of the assessed impacts for all selected UPS. For a more detailed interpretation of the results, we calculated the arithmetic average. The assessment results for each criterion were numbered on a Likert Scale from 0 to 3; they were considered as quasi-metric and further analysed as interval scaled data to calculate the arithmetic averages (Lisch, 2014; Schindler et al., 2016b). The independent samples of the two villages had non-normal distributions. Therefore, we used the nonparametric Mann-Whitney *U* test to analyse significant assessment differences.

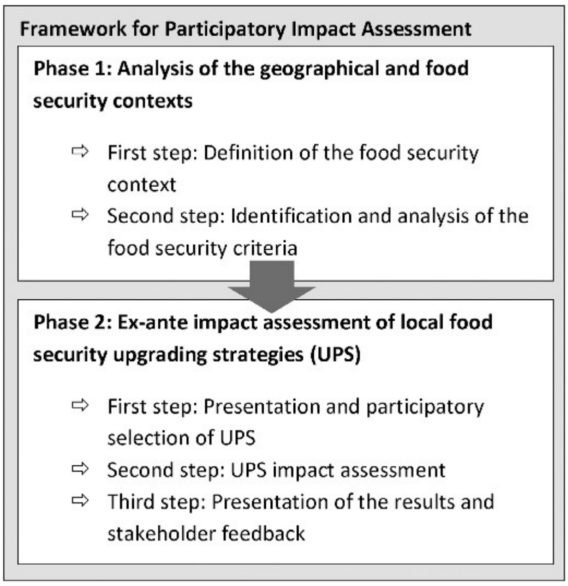

Fig. 1. Adapted schema of the FoPIA (Schindler et al., 2016b).

2.3. Case study site description

The majority of poor Tanzanian people live in rural areas, with approximately 83% of individuals living below the basic needs poverty line, while the smallholder agricultural sector provides 95% of the national food requirements (NBS, 2011). The case study site is located in semi-arid Tanzania and comprises the two case study villages of Ilolo and Idifu in the Chamwino district, which are situated in the semi-arid Dodoma Region and located on the central plateau of Tanzania. The food system is primarily based on sorghum and millet, and there is a long history of livestock husbandry (Mnenwa and Maliti, 2010). Crop production and livestock, particularly cattle, constitute the mainstay of the economy of the population living in Chamwino district by providing income, employment and food supplies. The region is particularly sensitive to food insecurity, which is mainly a result of unreliable rainfall (350–500 mm per year), low yields, a lack of knowledge of improved agricultural practices and low economic development. Dodoma has the highest rate of stunted children under the age of 5 years (approximately 80%) among all regions in Tanzania (URT, 2011). Dodoma is the only region in Tanzania where poverty appears to have increased between 1991 and 2003 (Minot et al., 2006).

3. Results

We analysed in a comparable manner the impact assessments by farmers and scientists of the UPS: rainwater harvesting (infiltration pits), fertilizer micro-dosing, improved processing devices (millet winnowing machine), the development of a new product (sunflower oil) and nutrition education (Table 1) in the two case study villages Ilolo and Idifu.

3.1. Infiltration pits

Farmers and scientists assessed the highest positive impact of the rainwater harvesting measure “infiltration pits” on *water availability*. The impact assessments of farmers and scientists for this UPS differed significantly for six out of the nine criteria (Table 3). The assessment differences were particularly high for the impacts on *yield, working conditions* and *soil fertility*. The scientists foresaw a large increase in production (*yields*) because of improved soil moisture conservation. The farmers also assumed production increases because of improved soil moisture conservation, but they also predicted that because of the higher workload needed to prepare the field with infiltration pits, they would not be able to cultivate the same field sizes as they would without having to construct the infiltration pits. Ultimately, the farmers felt constructing infiltration pits would not result in such a high yield increase, as assumed by the scientists. Interestingly, *yield* was assessed as second highest positive impact by the scientists, while it was the lowest assessed by the farmers.

The scientists assessed in average a slight negative impact on working conditions due to a higher workload. The farmers assumed that because of production increase, they would gain more money, which they could use to hire more labour to help prepare the fields. Additionally, they said that because of these soil moisture conservation measures, they would have less yield failure, which would again result in less work to balance these losses. The farmers foresaw very high positive impacts on *soil fertility*, particularly because of decreased soil erosion when applying this particular UPS. The scientists foresaw moderately positive impacts on *soil fertility*.

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Table 3
Ex-ante impact assessment results of smallholder farmers and scientists.

Criteria	Smallholder farmer				Scientists			
	N	Min	Max	Average	N	Min	Max	Average
Rainwater harvesting measure "infiltration pits"								
Yield	25	−2	3	0.92[a]	22	0	3	2.36[a]
Income	25	−1	3	1.60	22	0	3	2.05
Market participation	25	0	3	2.28	19	0	3	1.95
Food diversity	25	1	3	2.64[b]	22	0	3	2.09[b]
Social relations	25	−2	3	2.12	20	−2	3	1.70
Working conditions	25	−1	3	1.80[a]	21	−3	3	−0.10[a]
Soil fertility	25	2	3	2.88[a]	20	−2	3	1.40[a]
Water availability	25	2	3	2.92[c]	22	1	3	2.64[c]
Agro-diversity	25	0	3	2.40[b]	19	0	3	1.32[b]
Fertilizer micro-dosing								
Criteria	**Smallholder farmer**				**Scientists**			
	N	Min	Max	Average	N	Min	Max	Average
Yield	25	0	3	1.96	21	1	3	2.52
Income	25	−2	3	1.72	21	1	3	2.19
Market participation	25	−3	3	1.52	19	1	3	2.16
Food diversity	25	−3	3	1.40	20	0	3	2.20
Social relations	25	−3	3	1.60	19	−2	3	1.42
Working conditions	25	0	3	2.20[a]	20	−2	3	−0.15[a]
Soil fertility	25	0	3	2.40	21	1	3	2.43
Water availability	25	−3	3	0.16	19	−2	3	0.21
Agro-diversity	25	−2	3	2.36[a]	18	−1	3	1.00[a]
Improved processing devices "millet winnowing machine"								
Criteria	**Smallholder farmer**				**Scientists**			
	N	Min	Max	Average	N	Min	Max	Average
Yield	24	0	3	2.42[b]	20	0	3	1.50[b]
Income	24	0	3	2.25	20	0	3	2.25
Market participation	24	0	3	2.46	20	0	3	2.25
Food diversity	24	0	3	2.25[c]	20	1	3	1.90[c]
Social relations	24	0	3	2.08	17	−1	3	1.94
Working conditions	24	0	3	2.46	20	−1	3	2.10
Soil fertility	24	0	3	1.21[b]	18	0	2	0.22[b]
Water availability	24	0	3	0.58	18	0	2	0.17
Agro-diversity	24	0	3	2.04[a]	17	0	1	0.06[a]
New product development "sunflower oil"								
Criteria	**Smallholder farmer**				**Scientists**			
	N	Min	Max	Average	N	Min	Max	Average
Yield	23	1	3	2.43[a]	15	0	3	1.33[a]
Income	23	0	3	2.30	15	1	3	2.40
Market participation	23	0	3	2.13	15	2	3	2.53
Food diversity	23	0	3	2.35[c]	15	1	3	2.00[c]
Social relations	23	0	3	2.00	15	−1	3	1.69
Working conditions	23	−1	3	2.13[c]	15	−2	3	1.27[c]
Soil fertility	23	−2	3	1.70[a]	15	−1	1	0.13[a]
Water availability	23	0	3	1.13[c]	15	0	2	0.20[c]
Agro-diversity	23	−3	3	0.48	15	−1	2	0.27
Nutrition education								
Criteria	**Smallholder farmer**				**Scientists**			
	N	Min	Max	Average	N	Min	Max	Average
Yield	20	0	3	2.30[a]	18	0	3	0.72[a]
Income	20	0	3	2.20[a]	18	−2	3	0.44[a]
Market participation	20	−1	3	2.45[a]	18	0	3	0.39[a]
Food diversity	20	0	3	2.50	19	2	3	2.79
Social relations	20	−2	3	2.15	17	1	3	2.29
Working conditions	20	1	3	2.70[b]	19	−1	3	1.42[b]
Soil fertility	20	−3	3	0.25	17	0	2	0.18
Water availability	20	0	3	1.70[b]	17	0	3	0.24[b]
Agro-diversity	20	1	3	2.90[a]	17	0	3	0.82[a]

[a] Criteria with a significant difference ($\alpha \leq 0.001$).
[b] Criteria with a significant difference ($\alpha \leq 0.01$).
[c] Criteria with a significant difference ($\alpha \leq 0.05$).

3.2. Fertilizer micro-dosing

Farmers as well as scientists interpreted very high positive impacts on *soil fertility* due to fertilizer application. The scientists assumed the highest positive impact on *yield*. This was assessed as only moderately positive by farmers who explained the risk and their experiences with chemical fertilizer application during drought years, as well as the negative impact on *yields* if there was a lack of rain. We found two significant impact assessment differences in regards to the UPS fertilizer micro-dosing: *working conditions* and *agro-diversity*. While scientists assumed small negative impacts were caused due to surplus time needed for fertilizer application, the farmers explained that because of increased yields caused by fertilizer application, they are able to hire labour to help with the increased workload of fertilizer application, consequently decreasing their own workload.

In regards to *agro-diversity*, scientists interpreted only small positive impacts, while farmers asserted that if they would have access to fertilizer, they would also plant crops that they could not cultivate presently because of low soil fertility. Farmers explained also that because of secured yields, they would be willing to add other crops. This also explains why the highest impact was assessed on *agro-diversity* by farmers, while the scientists observed on average only a slight to moderate positive impact on *agro-diversity*.

3.3. Improved processing device "millet winnowing machine"

For the UPS "millet winnowing machine," farmers as well as scientists assessed on average very high positive impacts for *market participation*. Consequently, it also has a high positive impact on *income*. The farmers valued the very positive effect of decreased workload (improved *working conditions*) as the result of using a machine instead of doing the work manually. Farmers and scientists assessed the following impacts significantly differently for the food security criteria: *yield, food diversity, soil fertility* and *agro-diversity*. The difference was particularly high for *agro-diversity*. While the scientists did not see much relation between this UPS and this particular criterion, the farmers stated that because of time saved with the help of this processing machine, they could plant additional crops that they had not planted previously. They said also that the crop residues produced as a by-product of winnowing would add to *soil fertility*, which would enable them to plant crops in spots that they would normally avoid because of low soil fertility.

3.4. New product development "sunflower oil"

In regards to this above mentioned UPS, significant assessment differences were given for *yield, food diversity, working conditions, soil fertility* and *water availability*. The differences were particularly high for the impact assessment on *yield* and on *soil fertility*. The farmers assessed the highest positive impact on *yield* because of the increased income from sunflower oil production, which they would use to buy improved seeds that would deliver higher yields. The scientists interpreted the highest positive impact in regards to *market participation*. Scientists assumed no impact on *soil fertility*, while the farmers assessed a moderately positive impact. Because of higher income, they could afford fertilizer that would add to *soil fertility*. Furthermore, if sunflower heads were tilled under, soil fertility would also be improved.

3.5. Nutrition education

Scientists assessed the impacts on economic and environmental criteria to be quite low in comparison to farmers' assessments. Significant differences were assessed in regards to *yield, income, market participation, working condition, water availability* and *agro-diversity*. Farmers evaluated all of these criteria with higher positive impacts than scientists. Because of education, they assumed that the farmers would learn how to produce better (new cultivation methods) and more products, as well as how to diversify production. The new products could be sold at markets and become a new source of *income*. The integration of food wastes would add to *soil moisture availability*. The farmers explained also that the improved nutrition would add to the overall health of the family and would therefore improve their work rate (*working condition*).

4. Discussion

Kristjanson et al. (2002) argued that "[…] the typical approach to measuring impact of agricultural research has been to ask experts". Farmers are rarely involved during planning and realization of impact assessment. Involving farmers is often considered as a "[…] substitute for the adaptive end of the formal research spectrum[…]" in regard to final adaptation of a technology (Sumberg et al., 2003). We emphasize that the local population should participate in the planning phase. Our study showed several differences as well as similarities between farmers and scientists in regards to the UPS and their assessed impacts on food security criteria. The number of significant assessment differences for the UPS *rainwater harvesting measure "infiltration pits"* and *nutrition education* were particularly high in six of nine cases. This shows that farmers and scientists have considerably different views on the positive and negative impacts of these UPS. Scientists often impose their assumed theory of change that a new technology will lead to development (Millstone et al., 2010). However, in Table 3, we can see that farmers assume negative impacts of UPS, which were not considered by scientists and vice versa. We observed during the assessment that scientists would focus on direct causal impact chains of the UPS, while the farmers would additionally mention several indirect linkages that considered their complex living-environment, thus reflecting the whole farming system as well as the social and the environmental contexts (Hoffmann et al., 2007). For instance, while scientists assessed very high positive impacts on *yield* because of fertilizer application, the farmers also considered in their evaluation the high risk of lack of rain and chemical fertilizer application, which would increase yield failure even further during drought years compared to not applying fertilizer. In regards to the UPS *infiltration pits*, the scientists predicted mainly positive impacts on the criterion *yield* because the scientists took the following causal chain for granted: Infiltration pits will increase the soil moisture level and will therefore increase yields. However, the farmers argued that because of the increased workload to set up the *infiltration pits*, they would not be able to cultivate the same field sizes as in preceding years. This could in the end result in lower yields than in other years, particularly when there is a drought. During our work with the farmers, we became aware of their uncertainties, such as yield losses from fertilizer application during drought years. This consideration needs to be further explored.

In addition to using impact assessment to anticipate possible impacts and to make them explicit, an ex-ante impact assessment facilitates insights into the complex socio-environmental context of the local community (Reed, 2008). Additionally, Hoffmann et al. (2007) further argued that the main objective of the farmer is not only to produce more product but to improve the livelihood as a whole. This demands considerably more contextual understanding that only farmers have. In addition, the output-interest and -scale of the research activity also differs between farmers and scientists. While farmers seek adapted local solutions that have the most effective impact on their situation, scientists expect to generate solutions that can be scaled out, scaled up and published (Hoffmann et al., 2007). We therefore see bi-lateral ex-ante impact assessments as a valuable step before the implementation of new technologies to allow scientists to understand the aims and perceptions of farmers, to reflect whether the measure really meets the community's needs and priorities, and to make adaptations to provide a real benefit for farmers. The concerns of the local community need to be integrated and answered during the further implementation of the new technologies, for instance during trainings for farmers.

The impact assessment process itself provides a strong social learning tool, initiating structured thinking and knowledge exchange among participating farmer groups and between researchers and farmers (Schindler et al., 2015; Gibson, 2006; Bond et al., 2013; Bond and Morrison-Saunders, 2013).

For example, during our impact assessment with farmers, some researchers mentioned that the view of the farmers is interesting and that they themselves did not think about several mainly implicit aspects that were mentioned as potentials and risks by the community (Schindler et al., 2016b). Likewise, several researchers observed that farmers possess local contextual knowledge that is invisible from an outside perspective (Sumberg et al., 2003; Millstone et al., 2010; Hoffmann et al., 2007). To derive "user-useful" solutions, local knowledge should be considered equally necessary to scientific knowledge (Raymond et al., 2010). The farmers should be given the opportunity to assess the impacts before implementation; otherwise important community-level impacts will stay invisible (Becker et al., 2003) and may result in negative outcomes (Millstone et al., 2010). This consideration is not only useful before implementation but also for monitoring and evaluation. Furthermore, we emphasize that the different assessment results are interesting, but the essentials are the reasons behind the assessment results. Understanding this idea requires an open exchange between scientists and farmers to understand the farmers' tacit knowledge that comes from daily practices. A respectful integration of local knowledge and science will provide a more comprehensive understanding of complex systems (Reed, 2008). The active participation of farmers will not only support better adaption of activities to local conditions, but it will also raise public acceptance, a prerequisite for successful project implementation (Ridder and Pahl-Wostl, 2005).

5. Conclusion

Local communities are rarely involved during the planning and realization of research projects' impact assessments. The objective of our research was to show the impact assessment differences from farmers and scientists as well as the value of their complementary use to improve mutual learning for implementing suitable solutions. We observed that farmers and scientists have considerably different views on the positive and negative impacts of proposed agricultural UPS. While scientists focus mostly on direct causal impact chains of the UPS, the farmers consider indirect linkages that take their complex livelihoods into account. In addition to using an ex-ante impact assessment to anticipate possible impacts of project interventions and to make them explicit, it also facilitates insights into the complex socio-environmental context of a local community. Furthermore it is a social learning tool that can initiate structured thinking and knowledge exchange among participating farmer groups as well as between researchers and farmers. We therefore see an ex-ante participatory impact assessment as a critical step before implementation to adapt solutions to the local context and provide real benefits to local communities.

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5 Overall conclusion

The results of applying the transdisciplinary impact assessment approach FoPIA were presented for four different case study villages in rural Tanzania. The results show the benefit of the active involvement of local stakeholders during impact assessment. By applying this approach, locally-relevant food security criteria were elaborated in a constructive and interactive way. These criteria cover the three dimensions of sustainability (economic, environmental, social), while simultaneously representing the four food security dimensions (availability, access, utilization, stability), showing that rural communities think holistically and consider multiple criteria and dimensions related to food security. The farmers identified positive and negative sustainability impacts of the upgrading strategies on those food security criteria. The adapted FoPIA enabled a quick and transparent identification of trade-offs between the chosen upgrading strategies and priority food security criteria at the four case study sites. Furthermore, it supported anticipating possible impacts and facilitated insights into the socio-environmental context of a local community. The results of the sustainability impact assessments were considered valuable for adapting intended development interventions to the locality and reducing the assessed potential negative impacts. This research showed that impact assessment results cannot simply be transferred from one locality to another, even if the distance between the case study sites is very minimal, given that each locality has its own characteristics and particularities.

The interlinkage of local stakeholders' knowledge and scientific knowledge provides a more comprehensive understanding of complex and dynamic systems and processes and produces more relevant and effective practices. As shown in this thesis, farmers and scientists have considerably different views on the positive and negative impacts of proposed agricultural interventions (upgrading strategies). While scientists mostly focused on direct causal impact chains, the farmers considered indirect linkages that take into account their complex livelihoods. Furthermore, the adapted FoPIA was found to be a social learning tool that can initiate structured thinking and knowledge exchange among participating farmer groups as well as between researchers and farmers. This research showed that sustainability impact assessment is a critical step prior to project implementations, enabling adapting upgrading strategies to the local context and providing real benefits to local communities.

5.1 Research results and their relation to the theoretical context

5.1.1 FoPIA and social learning theory

The adapted FoPIA approach used allowed for social interaction, which is supposed to be a key aspect of social learning theory. FoPIA supported the interaction of and learning from different people with different viewpoints. The application of strict selection criteria facilitated a diverse composition of farmer groups in terms of knowledge, experiences and backgrounds. The farmers who participated during the workshops provided the feedback that they learnt many new aspects during this intensive assessment session. Additionally, the involved scientists mentioned that several farmers' perceptions were unknown to them, which again supports the importance of knowledge co-generation (Chambers 2012). The approach also allowed identifying different priorities of different stakeholder groups within a community, such as differences between male and female farmers' scorings across the two regions. Hence, through such a participatory process with active community involvement stakeholder- and locally-specific information can be gathered (Chambers 2012, 1994; Agol et al. 2014).

Webler et al. (1995) also described criteria that serve as precondition for effective social learning. Besides c*ognitive enhancement*, these also include *moral development* and the notion that the process should be led by a sense of *fairness* and *competence*. *Cognitive enhancement* - the acquisition of knowledge - was definitely triggered during the process. *Fairness* and *competence* was also a major focus during the impact assessment. The moderator encouraged all farmers in the workshop to participate and the secret rating part allowed all participants to give their own opinion without being influenced by dominant characters. The aspect and level of *moral development* cannot be sufficiently analysed. As defined by Webler et al. (1995), *moral development* demands setting aside the individual interests and acting for the good of the community, leading from uncoordinated individual actions to collective actions that reflect collective needs and understandings. Within this research, the moderator of the workshops emphasised the selection of criteria and the impact assessments from a community perspective. Of course, this is still influenced by individual experiences. The author of this thesis agrees with the argumentation by D. P. Lawrence (2000) that communications and participation may clarify positions but they will not overcome fundamentally different value positions and views, even with the most sophisticated methodological approach.

5.1.2 FoPIA and communicative planning theory

As an ex-ante impact assessment, FoPIA is a methodological framework used during the planning phase, supporting strategic planning towards sustainable development in a given context. Farmers are still rarely involved during the planning and realisation of impact assessment (Sumberg et al. 2003; Kristjanson et al. 2002). With FoPIA, negative side effects may be discovered that are invisible from the external perspective of development organisations or researchers who are planning development interventions (EIARD, 2003; Millstone et al., 2010).

During the application of FoPIA, a discussion, argumentation, negotiation and exchange on experiences, information and values was triggered in a moderated context. It was also very important that the researchers and the technical experts remained in the background during the impact assessment process and that a qualified moderator guided the impact assessment. Nevertheless, power relations are always present between researchers and farmers, as well as within the farmer groups (Morgan 2012; Richardson 2005; Hansen et al. 2013). The moderator focused on the active involvement of each participant during the process. In order to gain an insight into each and everybody's opinion regarding the impacts, secret rating rounds and - if necessary - individual interviews on rating results were conducted after finalising the workshops. A successful ex-ante impact assessment requires an empathetic moderator who knows the local context (Becker et al. 2003; Schindler et al. 2016c). It is absolutely necessary to equip practitioners and planners as capable moderators to work in the face of power (Hansen et al. 2013; Fischler 1989).

5.2 Conclusion on research question and hypothesis

The following research question and hypothesis guided this PhD thesis:

Does sustainability impact assessment with farmers have an added value in agricultural intervention planning for improved food security?

The dissertation results show that sustainability impact assessment applied with farmers has an important added value for agricultural planning for improved food security. It was proven that the application of a participatory ex-ante impact assessment with the local community provides an in-depth insight into the food security situation and challenges and helps to identify negative and positive impacts of planned upgrading strategies prior to their implementation. Therefore, it supports the planning for better adapted solutions to enhance the food situation and avoid negative outcomes. Nevertheless, it cannot be assured whether food security will be achieved, because several aspects that have a severe impact on agriculture - such as the climate, plant pests or conflict - may have disastrous impacts on the food security situation.

This research followed the **hypothesis** that:

Sustainability impact assessment supports project planning and developing solutions for sustainable and locally adapted agricultural development.

Based upon the research results of this dissertation and the argumentation above, this hypothesis could not be disproven. As a framework for sustainability impact assessment applied at the local level, FoPIA supports project planning. The assessment of positive and negative impacts along the food security criteria - which simultaneously covered all three sustainability dimensions – provides a deep insight into possible risks and advantages that may occur after the implementation of proposed upgrading strategies. Applied during the planning phase, these important results need to be seriously taken into account for the adaptation and adjustment of critically-assessed agricultural upgrading strategies. This will not only lead to improved impacts but also a broader acceptance and ownership of the proposed measures within the community.

5.3 Outlook

The realities of farmers are local, complex, diverse and dynamic. Our research has shown the multi-dimensionality of food security from the farmers' perspective. Furthermore, the interactive participatory approach has provided valid insight into values, priorities and preferences. Only when further development measures respond and respect theses values as well as priorities and when doubts by farmers are seriously taken into account can they have the potential to be successful in the local context (Chambers 1995, 2012). Many inter-relationships and much local information are simply invisible to researchers, whereas based upon the daily challenges that they face communities have a more holistic view of their livelihoods (Millstone et al. 2010). The involvement of the local community - as the intended beneficiary group of certain development measures - is absolutely necessary, not only to adapt solutions but also to raise ownership and acceptance. As highlighted by Mayoux and Chambers (2005), the new impact assessment agenda for pro-poor development and improving practice necessarily requires participation by poor women and men in deciding priorities and identifying upgrading strategies. However, it needs to be highlighted that it is not only the involvement itself and the fact that people are "somehow" participating that counts, but rather the way and process in terms of how the community is involved. As emphasised by Tippett et al. (2005), the outcome of a decision is strongly dependent on the process through which the decision is derived. "This is often neglected in planning and in the development of decision support tools which only focus on the final process of decision-making" (Joss and Brownlea 1999). Nevertheless, "it has long been recognised, however, that decision is only the immediate purpose of impact assessment and that the influence of impact assessment can extend well beyond individual decisions. It may also influence the values and behaviours of organisations and society at large through processes of learning and change" (Bartlett and Kurian 1999).

Annexes

Annexe 1

Review article: Methods to assess farming sustainability in developing countries. A review.

Schindler, J., Graef, F., & König, H. J. (2015). Methods to assess farming sustainability in developing countries. A review. *Agronomy for Sustainable Development*, 1-15, doi:10.1007/s13593-015-0305-2.

Methods to assess farming sustainability in developing countries. A review.

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Abstract

Sustainable agricultural development is fundamental to food security and poverty alleviation, notably in developing countries. Many development initiatives focus on the enhancement of smallholder production and productivity because the majority of poor people in developing countries live in rural areas where agriculture is the main source of livelihood. The consequences of these development initiatives need to be assessed before implementation to reduce the risk of possible negative impacts. This can be done by applying ex-ante sustainability impact assessment. Here we compare methods of assessment of sustainability impact for farming interventions. We review methodological approaches and verify whether the requirements of sustainability impact assessment theory are fulfilled. Our major points are: 1) main methodological approaches do not fulfill the requirements defined in the theoretical sustainability impact assessment discourse. 2) The active involvement of different stakeholder groups throughout the assessment process and the possibility of learning and exchange are fundamental to sustainability impact assessment. 3) The institutional dimension of sustainability is not yet sufficiently integrated. We therefore suggest institutional criteria and indicators to be also considered in the sustainability impact assessment framework. We argue that sustainability impact assessment, respecting the interactive involvement of all stakeholder groups throughout the whole process, is a compulsory element in project planning for a sustainable agricultural development in developing countries.

Keywords: impact assessment; smallholder agriculture; sustainability; evaluation; food security; decision support

Contents

1. Introduction

Sustainable agricultural development is linked to the improvement of food security and poverty alleviation, especially in developing countries where 98% of the chronically hungry population lives (WSSD 2002; FAO 2013). Sustainable agriculture is socially just, ecologically sound, economically viable and a paradigm that aims to produce the food needed to achieve food security (IAASTD 2009; Cavatassi 2010; FAO 2013). In developing countries, mainly smallholder farmers supply local and national markets by providing 80% of the food (IAASTD 2009; Dethier and Effenberger 2012; IFAD and UNEP 2013). In Africa, 90% of agricultural production is derived from smallholder farmers, where the average farm size is about one hectare (IAASTD 2009; IFAD and UNEP 2013). It is a well known contradictory fact that farmers who supply the main part of agricultural produce are the poorest and most hungry population group within developing countries (IAASTD 2009; Dethier and Effenberger 2012; IFAD and UNEP 2013). Several development initiatives focus on enhancing agricultural production and productivity of smallholder farmers in developing countries. Because their livelihoods are fragile, the impact of development initiatives needs to be assessed before implementation, with the primary goal of increasing the probability that these initiatives will improve the livelihoods of impoverished people in the project regions, and to avoid negative impacts (EIARD 2003). This can be done by applying impact assessment in order to adapt development interventions to the local context and to steer towards sustainable development (Pope et al. 2013). There is a great emphasis on the suitability and sustainability of project interventions, and assessing this requires appropriate methods. Theory and practice of impact assessment are expanding rapidly. There is a large number of impact assessment methods related to different types: environmental, social, economic […]; levels: local, national, regional […]; targets: policies, programs, projects […] and timing: ex-ante, during and ex-post. The new approach to impact assessment is sustainability impact assessment, which places emphasis on delivering positive net sustainability gains now and in the future (Bond et al. 2012).

Today we see a wide diversity of practices and methodology in the field of sustainability impact assessment (Sadok et al. 2008; Pope et al. 2013). There has been a lot more focus on ex-post than on ex-ante impact assessment at the project level (Silvestrini 2011). Presently, there are no internationally established standards regarding the methodological approaches for carrying out ex-ante evaluations at the project level (Silvestrini 2011; GIZ 2013). Pope et al. (2013) highlight that "[…] the lack of consistent and agreed methodology is perceived as a strength allowing for flexibility and context-specific approaches". The number of methods and tools available is continually increasing (Sadok et al. 2008). We find several approaches even when narrowing the field of interest down to ex-ante impact assessment for the sustainability of agricultural development interventions.

The objective of this paper is to analyze and compare existing ex-ante sustainability impact assessment methods. We verify whether the requirements of sustainability impact assessment, as given in the recent theoretical discourse, are represented in sustainability impact assessment approaches applied. We analyzed 10 methods currently applied within the scope of sustainable agricultural development, with a focus on crop farming in developing countries. Although we are aware that analyzing only 10 methods does not address all existing approaches, it will nevertheless demonstrate the variety of methods that are currently applied in the context of sustainability impact assessment. We first present the current state of the theory of sustainability impact assessment, followed by an analysis of the methodological approaches. Then we critically discuss the methods with respect to the theoretical requirements of sustainability impact assessment. Finally, we outline the utility and the informative value of the different approaches in regards to their potential of achieving sustainable development.

To identify and select sustainability impact assessment methods applied in the context of developing countries, we searched in scientific databases, such as the ISI Web of Science and Scopus, using the following keywords: (ex-ante) impact assessment, evaluation, sustainability, agriculture, (small scale) farming, strategic project planning, food security, decision support, project assessment. In addition, we searched on the websites of national and international institutions for research and implementation to find methodological approaches for the ex-ante impact assessment of development projects. We limited our focus to the methodological approaches that have been applied in the context of agricultural development initiatives in developing countries. To present the current state of practice, the case studies in developing countries date from 2000 until 2013. Methods that have been widely used for project assessment but which only focus on one particular dimension of the sustainability paradigm (for instance only on economic aspects) were excluded from this review.

We analyzed the 10 methods with regard to the following characteristics:

General application characteristics including objectives of the method; thematic agricultural sector of application; moment of application [ex-ante, during, ex-post]; time needed for application; spatial analysis scale; data input and analysis [qualitative, quantitative]; applying user; end user of results; timely horizon of assessed impacts.

Representation of sustainability dimensions including number of sustainability pillars; number of indicators per dimension; indicators predefined or open to be defined; interrelation of dimensions; context-relatedness of indicators.

Level of stakeholder involvement including representation of involved stakeholder groups; moment of stakeholder involvement during the assessment; level of interactive stakeholder involvement; integration of collective learning process; stakeholder’s influence on indicators, assessment and decision making.

2. Theoretical background of ex-ante sustainability impact assessment

2.1 Definition

Sustainability impact assessment is a process that supports decision making towards sustainable development in a given context. The International Association for Impact Assessment (IAIA) defines impact assessment in general as a process that identifies future consequences of an intended action. The terms “impact” and “effect” are frequently considered as synonyms (IAIA 2009). In the context of project planning, “ex-ante” impact assessment is used in order to predict environmental, social and economic consequences of an intervention in order to approve, adapt or reject a development project proposal. The use of impact assessment of projects dates back to the 1950s (Maredia 2009). According to the IAIA (2009), impact assessment procedures generally aim at providing information for decision making, the participation of the public, and the contribution to sustainable development as primary goals.

Sustainability impact assessment is the only type of impact assessment that considers and integrates the three pillars of sustainable development equally. It is simply defined as the process that steers decision-making towards sustainability, as well as ensuring net sustainability gains in the present and the future (Ness et al. 2007; Hacking and Guthrie 2008; Bond and Morrison-Saunders 2011; Bond et al. 2012; Singh et al. 2012). Sustainability impact assessment does not only consider environmental, social and economic implications, but also analyses the interrelations between the three pillars (Pope et al. 2004). It is becoming common as a decision-making procedure whose goal is to anticipate the sustainability of policies, plans, projects, programs or a current practice or activity (Pope et al. 2004; Hacking and Guthrie 2008; Bond and Morrison-Saunders 2011; Bond et al. 2012). Gibson (2013) lists six imperative criteria of sustainability impact assessment:

- The development initiative must have a positive contribution to a sustainable future;
- All key factors that affect a sustainable future as well as their interlinkages are considered;
- The interdependence of ecology, economy and society is respected;
- Trade-offs are minimized;
- Context is respected, and effective criteria in regard to the people and the context concerned are used;
- Participation at all levels from government to society is emphasized, and simplistic technical procedures are avoided.

In relevant literature, the potential and limitations of quantitative versus qualitative research have been discussed, as have reductionist versus holistic approaches for sustainability impact assessment (Ness et al. 2007; Gasparatos et al. 2008; Bond et al. 2012; Bond and Morrison-Saunders 2013b).

2.2 Reductionism vs. complexity

Reductionism in sustainability impact assessment means that only a few indicators are used to assess the sustainability of a whole system. They simplify, quantify, analyze and therefore facilitate the communication of complex and complicated information (Singh et al. 2012). Bebbington et al. (2007) and Singh et al. (2012) argue that there is a widely recognized need for individuals, organizations and societies to find models, metrics and tools in order to assess sustainability. The risk of quantitative and reductionist assessment is that it can lose sight of the complex and often characteristic picture of reality, as well as what is important at the local level (Cosyns et al. 2013). Analytical tools and techniques that only use quantitative approaches, often reductionist, are less important in sustainability impact assessment, and decision-making has to follow more qualitative analysis (Cashmore 2004; Bond and Morrison-Saunders 2011; Bond et al. 2012). Bell and Morse (2008) as well as Bond and Morrison-Saunders (2013b) emphasize that pluralism is central to sustainability impact assessment in order to get a broader understanding of the given context. Sustainability impact assessment gives direct, effective and efficient attention to social, economic and ecological factors and their interaction, and it therefore supports the development of site-adapted solutions. But pluralism may also be considered as a weakness due to its reliance on (often costly and time demanding) stakeholder involvement strategies in order to integrate the diversity of a context. A reductionist approach often simplifies a system in an effort to have clearly defined components for analysis, while the holistic approach often comprises more qualitative aspects to reflect the complexity of a system. The broad scope of the assessment allows a more holistic picture, which should reduce the need for trade-off decisions (Bond et al. 2012). Therefore sustainability impact assessment should provide sufficient space and time with stakeholder groups to understand the local context and to elaborate indicators, which fully represent the analyzed system. The number and nature of indicators are not restricted or predefined, but need to be elaborated in an interactive process. Sustainability impact assessment allows complexity and enables the collection of primary data useful for a subsequent qualitative data analysis.

2.3 Stakeholder involvement

Spohn (2004 cited Singh et al. (2012)) distinguishes between a “top-down” and a “bottom-up” approach in the assessment procedure. The top-down approach “[…] enables experts and researchers to define the overall structure for achieving the sustainability and subsequently it is broken down into set of indicators” while a “bottom-up approach requires systematic participation of various stakeholders to understand the framework as well as the key sustainable development indicators”. Different authors emphasize the importance of “embedded learning” due to stakeholder involvement in the practice of sustainability impact assessment (Gibson 2006; Bond et al. 2012; Bond and Morrison-Saunders 2013a). Sustainability cannot be simply measured by categories and indicators that are invented on the drawing board. The impact assessment process is therefore highly context-related and needs active stakeholder involvement (Bond et al. 2012). As context changes with time, so too does sustainability. Adaptation and flexibility, willingness to learn and changing perspectives are therefore essential requirements within the sustainability impact assessment process. The view of all affected parties needs to be integrated (Gibson et al. 2005; Gibson 2006; Bond et al. 2012).

Thus, it is recommended that stakeholder involvement be considered from the planning phase through to the final evaluation, which is so critical to sustainable development, and thereby move away from simple technocratic decision-making towards a more dialogic approach (EIARD 2003; Bond and Morrison-Saunders 2011; Kiara 2011; Morgan 2012). Bebbington et al. (2007), Maredia (2009) and Singh et al. (2012) mention that indicators of sustainable development should be selected, revisited and refined upon based on the appropriate communities of interest. Stakeholder involvement is not only important in order to identify different perspectives, objectives and values, but also to align those different views and to reduce the chance that a conflict will arise. Participation adds to the understanding of the project itself, and thereby helps with the acceptance of decisions and ownership. The process ensures that results are locally adapted and relevant, and therefore contribute to the overall sustainability (Cashmore et al. 2009; Cosyns et al. 2013; Stoeglehner and Neugebauer 2013). This also requires a learning attitude to be shown by all the stakeholders involved. Stoeglehner and Neugebauer (2013) argue that stakeholder implication should even be added as “the fourth pillar“ of sustainable development. Stakeholder involvement may have different levels of intensity. Considering stakeholder involvement in the context of sustainability impact assessment means to actively involve stakeholders at all stages of a development initiative. Simply informing and consulting them is insufficient (Stoeglehner and Neugebauer 2013).

3. Methodological approaches

In the following section, we briefly describe the objective and the methodological procedure of 10 approaches used in sustainability impact assessment. We present them regarding their objectives, context of application (thematic agricultural sector of application, moment of application [ex-ante, during, ex-post], time needed for application, data input, spatial analysis scale, analysis [qualitative, quantitative], applying user, end user of results), indicators, stakeholder involvement and case study examples. The results are presented in Table 1.

Table 1 Overview of the methodological approaches used in the context of ex-ante sustainability impact assessment

Criteria	Method 1	Method 2	Method 3	Method 4	Method 5
Method	PIA	FoPIA	PIPA	DESIRE-DSS (WOCAT)	MESMIS
Author, year	(OECD 2007)	(Morris et al. 2011) (König et al. 2012)	(Douthwaite et al. 2007a) (Alvarez et al. 2010)	(Schwilch et al. 2009) (Schwilch et al. 2012b)	(López-Ridaura et al. 2002)
Thematic agricultural sector	Poverty reduction	Sustainability of land use management/ strategies/ policies	Enhancement of rural livelihood	Sustainable land management (desertification mitigation strategies)	Small farmer sustainable natural resource management systems
Objective of Method	To improve intervention's poverty orientation and assess impact on poverty reduction	Assessing the impact of policy-driven farming practices on sustainable development	Improvement of planning and evaluation of complex interventions in the water and food sectors	Participatory process of appraising and selecting sustainable land management measures	Translation of general principles of sustainability into locally specific operational definitions and practises
Moment of application	Ex-ante, monitoring, ex-post	Ex-ante	Ex-ante, monitoring, ex-post	Ex-ante	Ex-ante, monitoring, ex post
Estimated time for application of framework	2-3 weeks/ locality	4-6 months/ locality	3 days/ locality	2-3 months/ locality	Not given
Indicators	Mainly economic and social dimension, indicators predetermined, number restricted	Economic, social, environmental dimensions, indicators not predetermined, limited to a number of 9 indicators	Economic, social, environmental dimensions, indicators not predetermined, number not restricted	Economic, social, environmental dimensions, indicators not predetermined, number not restricted	Economic, social, environmental dimensions, indicators not predetermined, not restricted
Stakeholder involvement (*1)	Medium to high	Medium to high	High	High	High
Data type	Primary and secondary	Primary and secondary	Primary	Primary and secondary	Primary and secondary
Level of application (*2)	Local, regional	Local, regional, national	Local	Regional	Farm, local
Analysis type (*3)	Qualitative and quantitative	Qualitative and quantitative	Qualitative	Qualitative and quantitative	Qualitative and quantitative
Applying user	Donor	Research	Research	Research	Research
End user of results	Donor, policy	Policy, farmers	Technical advisors, researchers, farmers	Research, policy, donor, technical advisor, farmers	Research, technical advisor, farmer
Case study example	Ghana, Brong-Ahafo (Osei-Akoto and Gottmann 2010)	India, Indonesia, Kenya, Tunisia, China (König et al. 2013)	Northern Nigeria (Douthwaite et al. 2007b)	China, Yan River Basin (Schwilch et al. 2012b)	Several countries in Latin America (Astier et al. 2011)
Assessment time-perspective (*4)	"short-term", "medium-term"	"Flexible"	"2 years" "After the project has ended"	"Short term (up to at least 10 years), long term (20 years) "	"Short term", "long term"

Criteria	Method 6	Method 9	Method 7	Method 8	Method 10
Method	ScalA	NUANCES	RISE	Farm-Images	TOA-MD 5.0 Model
Author, year	(Crewett et al. 2011)	(Giller et al. 2011) (Giller et al. 2006)	(Häni et al. 2003)	(Dogliotti et al. 2005)	(Antle 2011)
Thematic agricultural sector	Scaling up potential of sustainable crop production systems	Sustainable farm management and technology identification	Sustainability of agricultural enterprises	Sustainable farming systems	Sustainability of agricultural technologies and environmental change

Table 1 (continued)

Objective of Method	Systematic evaluation, communication and dissemination of successful agricultural practices at community level	Assessment of feasibility, impact and trade-offs of changing agricultural management and identification of most promising management	Holistic improvement of sustainability in agricultural production	Impact assessment of current levels of farm resource endowment on the possibilities for sustainable development and on the resource-use efficiency at farm scale	Adoption estimation and impact assessment of crop varieties on the poverty levels and the sustainability of agricultural systems
Moment of application	Ex-ante	Ex-ante	Ex-ante	Ex-ante	Ex-ante, ex-post
Estimated time for application of framework	App. 1 h/ person	1 year/ locality	3-4 h/ farm, whole process 2 days/ farm-enterprise	Not given	"Several weeks, depending on amount of data"
Indicators	Economic, social, environmental dimensions, indicators predetermined, number restricted	Focus on environmental and economic dimensions, indicators predetermined, number restricted	Economic, social, environmental dimensions, indicators predetermined, number restricted	Focus on environmental and economic dimensions, indicators predetermined, number restricted	Economic, social, environmental dimensions, indicators predetermined, number restricted
Stakeholder involvement (*1)	Low to medium	Medium	Low to medium (results are discussed with farmers and other stakeholders)	None to low	None to low
Data type	Primary	Primary and secondary	Primary and secondary	Primary and secondary	Secondary
Level of application (*2)	Local, regional	Farm, local	Farm	Farm	Farm, local and regional
Analysis type (*3)	Qualitative and quantitative	Qualitative and quantitative	Quantitative	Quantitative	Quantitative
Applying user	Research, donor, technical advisor	Research	Research, technical advisor	Research	Research
End user of results	Research, donor, implementing institution	Donor, implementers, farmers	Farmer, technical advisor	Farmers, technical advisors	Research, policy
Case study example	Tanzania, Morogoro and Dodoma (Bringe et al. 2006)	Vihiga district, Western Kenya (Rufino et al. 2007)	Nilgiris, Tamil Nadu, India (Häni et al. 2007)	South Uruguay, Canelón Grande (Dogliotti et al. 2005) (Dogliotti et al. 2006)	Machakos,Kenya (Antle 2011)
Assessment time-perspective (*4)	3-5 years	"Short-term (1 season), medium-term (1–5 years), long-term (5–50 years) "	"1 year of production"	"Flexible"	"Flexible"

(*1) Stakeholder involvement: high (all relevant stakeholders involved at all assessment stages), medium (some stakeholders at several assessment stages), low (one stakeholder group at one assessment stage), none

(*2) Level of application: Local: community level; regional: sub-national level

(*3) Analysis type: Quantitative and qualitative analysis: *Quantitative research deals with the collection and analysis of data in numeric form. It tends to emphasize relatively large-scale and representative sets of data. Qualitative research deals with collecting and analyzing non-numeric information. It tends to focus on exploring, in as much detail as possible, smaller numbers of instances or examples, and aims to achieve "depth" rather than "breadth"(Blaxter et al. 1996).*

(*4) Assessment time perspective: Time perspective given as mentioned by author of methodological approach

Ex Ante Poverty Impact Assessment (PIA)

The PIA guideline developed by the OECD (2007) intends to provide a framework that integrates the already existing approaches of different donors, their procedures and terminologies. PIA is a process that examines the intended and unintended consequences of projects, programs, sector interventions and policy reforms, and focuses on impoverished and vulnerable people. The OECD considers five poverty dimensions: economic, human, political, socio-cultural and protective security, whereby gender equity and environmental sustainability cut across all dimensions of poverty.

PIA is based on balancing existing quantitative and qualitative information to achieve a sound and reliable assessment. It is an iterative process involving decision-makers and stakeholders from both donor and partner countries. PIA consists of five steps:

1. Outline the poverty situation and the relevance of the intervention.
2. Identify stakeholders and institutions.
3. Summarize the process by which the interventions are expected to influence the target group (transmission channels: prices, employment, transfers, access, assets, authority and productivity).
4. Outline the likely results on the stakeholder groups and their ability to escape from or to avoid poverty: economic-, human-, political participation-, security capabilities (to lessen vulnerability).
5. Present the impacts of the intervention on the Millennium Development Goals regarding extreme poverty and hunger, primary education, gender equality/ empowerment of women, child mortality, maternal health, HIV/AIDS, malaria/ other diseases, environmental sustainability, and global partnership.

Impacts of the intervention are assessed in terms of their “transmission channels”, the enhancement of “stakeholders capabilities“ as well as the improvements related to the Millennium Development Goals. The PIA results are summarized in simple matrices.

Framework for Participatory Impact Assessment (FoPIA)

Originally FoPIA was developed for land-use policy impact assessment in Europe. In this context the framework was described by Morris et al. (2011). At the same time, the FoPIA framework was adapted by König et al. (2010) and further developed to be applicable in the developing context (König et al. 2012; Purushothaman et al. 2012; König et al. 2013). FoPIA is structured around the DPSIR framework (Driver-Pressure-State-Impact-Response) (OECD 1993). It considers the relationships between environmental, economic and social issues, as well as national and regional sustainability priorities. By exploring alternative scenarios, the FoPIA aims to inform stakeholders about possible sustainability trade-offs, compromises and possible win-win situations. During the participatory and iterative process, alternative land-use scenarios are elaborated, and assessment criteria and indicators are developed and evaluated. Finally, the plausibility and the acceptability of the impacts are analyzed, and recommendations for improved decision-making then formulated. The procedural steps of FoPIA are:

1. Nationally and regionally relevant scenarios are identified and analyzed together with stakeholders.
2. Criteria based on land-use functions that present the key social, economic and environmental functions of land are elaborated. Stakeholders rank the perceived importance of each criterion for the sustainability of the region.

3. Assessment indicators are assigned to the land-use function criteria (expert-based).
4. Impacts on each scenario (ex-ante) are assessed using indicators ranked by stakeholders, while the definition of the time horizon remains flexible.
5. Land-use function criteria are re-evaluated and scored with the knowledge of trade-offs.
6. Reflection on the final results with stakeholders.

Figure 1 Ex-ante sustainability impact assessment workshop: Example of a workshop applying the Framework for Participatory Impact Assessment (FoPIA). The participants elaborate in a participatory process the sustainability criteria relevant in their locality.

Participatory Impact Pathways Analysis (PIPA)

PIPA (Douthwaite et al. 2007a; Alvarez et al. 2010) is a methodological approach that can be applied at different stages of a project cycle: planning (ex-ante), monitoring, and ex-post evaluation. With PIPA, an outcome and impact logic model is developed that describes how the project's outcomes will be scaled out (horizontal spread of project outputs, i.e. farmer to farmer) and scaled up (vertical institutional expansion) to achieve environmental, social and economic impacts. Stakeholders are involved throughout the whole process developing all the results. According to Alvarez et al. (2010), stakeholders in PIPA are defined as: next users, end users, politically important actors and project implementers. The procedural steps of PIPA are:

1. Stakeholders elaborate a problem- or objective tree that links the problem to be addressed by the project to the socio-economic and environmental situation. Further outputs and finally the outcomes of the project are developed.
2. Elaboration of network maps showing how actors, relationships and interactions influence the general environment for the new knowledge or technology.
3. The two aforementioned perspectives are integrated via an outcomes logic model that describes the project's strategies, knowledge and practice changes, as well as outputs and outcomes associated with realizing the project's vision. A monitoring and evaluation scheme is developed on the basis of the outcomes logic model.

DESIRE-Decision Support Systems (DESIRE-DSS)
DESIRE-DSS is a three part participatory methodology for selecting sustainable land management options. The approach was elaborated in the context of the EU-DESIRE project (www.desire-project.eu) and applied in 16 case studies in 14 countries within the World Overview of Conservation Approaches and Technologies network (WOCAT: www.wocat.org). The methodology was presented by Schwilch et al. (2009). It is a practical, structured and flexible methodology that can be applied in diverse contexts. The methodological procedure emphasizes a multi-stakeholder-learning process (land users, technicians, researchers, governmental and non-governmental officials) and combines in its solutions local knowledge with global expertise. DESIRE-DSS provides a pragmatic approach that considers time and financial restrictions, as well as the limited availability of facilitators and experts that need to guide the process. The procedure consists of constituent parts (Schwilch et al. 2012a):

1. Identify land degradation problems and existing and potential solutions: three-day workshop with a series of exercises. Linking scientific and local knowledge makes it possible to derive a range of alternative measures and mitigation strategies.
2. Evaluate and document the identified existing and potential prevention and mitigation strategies in the two to three months following the workshop by using questionnaires and a database system developed by WOCAT. Then appraise the ecological, economic and socio-cultural advantages and disadvantages of the strategies identified.
3. Participatory selection of potential options to test the implementation by weighing relevant criteria (e.g. technical requirements, costs and benefits of implementation, social acceptability, etc.) and ranking the presented strategies while taking into account the technical, bio-physical, socio-cultural, economic and institutional dimensions.

MESMIS framework
MESMIS (Spanish acronym for Indicator-based Sustainability Assessment Framework) was developed by the Interdisciplinary Group for Appropriate Rural Technology (GIRA) and presented by López-Ridaura et al. (2002). It is an iterative, holistic and interdisciplinary framework for evaluating sustainability to improve the design and the implementation of development projects (Astier et al. 2012). The determination of sustainability criteria and indicators varies according to the approach followed by the evaluation team and is specific for each case study. The framework allows for the derivation, measurement and monitoring of sustainability indicators, and is often applied in peasant natural resource management systems. Sustainability is not measured per se, but assessed through the comparison of two or more systems. Sustainability is here defined by: productivity, stability, reliability, resilience, adaptability, equity and self-reliance (self-empowerment) (López-Ridaura et al. 2002). López-Ridaura et al. (2002) and Astier et al. (2012) present the MESMIS operational structure consisting of six steps forming a cyclical process:

1. Define the evaluation objective, the context and the system under analysis: Identify existing and alternative management systems (components, inputs, outputs, socio-economic characteristics) and their socio-environmental context; identify spatial and time span of evaluation.
2. Determine the system's critical features in relation to sustainability attributes: productivity, stability, reliability, equity, adaptability and self-reliance.
3. Select diagnostic criteria and, based on these strategic indicators, address the seven sustainability attributes and the social, economic and environmental dimension.

4. Measure indicators and monitor: Measurement techniques are flexible and vary from literature review, direct measurement or simulation model use to participatory group techniques in the field. The dynamic consequences of management, thresholds and trade-offs are elaborated.
5. Integrate the results by means of multi-criteria graphic tools: Quantitative, qualitative and graphical as well as mixed procedures can be used to integrate results. Indicators are presented in a AMOEBA diagram (Ten Brink et al. 1991) to demonstrate the present and the alternative system at the same time, and compare the indicator features.
6. Offer conclusions and recommendations that reflect on how the different systems compare in terms of sustainability, main limitations and possibilities. A selection of scenarios and a translation into adaptive or corrective actions to improve the natural resource management system is then carried out.

ScalA

ScalA is a tool that aims to systematically evaluate, communicate and disseminate successful agricultural practices at a community level. ScalA was developed within the framework of two research projects (www.sustainet.org). The tool was then adapted and applied in further research projects (www.reacctanzania.com, www.better-is.com). The present state of the tool described here is the version of the ReACCT project and deals with the scaling-up of good agricultural practices (Crewett et al. 2011). It is specifically designed for the evaluation of an enhanced crop production system prior to its implementation. It compares specific requirements of a crop-production system and the specific conditions that are relevant for the production in a certain locality. ScalA argues that an intervention is sustainable if it enhances at least one of the three sustainability dimensions (environmental, economic and social) without the deterioration of another (Crewett et al. 2011). The potential of scaling-up is defined by 61 success indicators. Those indicators are linked to preconditions for the project’s successful implementation, namely the financial, human, institutional and infrastructural preconditions. ScalA consists of eight steps:

1. Step 1: Sustainability assessment regarding 5-7 indicators for each sustainability dimension (environmental, economic, social).
2. Step 2-5: Climate change responsiveness assessment (project contribution to adaptive capacity, resilience to climate change, employment of climate change adaptation strategies and adoption of greenhouse gas mitigation measures). For the steps 2 to 5, factors, indicators and key questions are given.
3. Step 6-8: Assessment of the scaling-up potential (fulfillment of the basic requirements for project implementation; assessment of how the scaling-up factors relate to financial aspects, human resources as well as institutional and infrastructural considerations). In step 8, the actual situation is compared with the optimal situation for scaling up.

The final outcome of the ScalA tool is a rating figure that enables a comparison between the failure or success of the analyzed project.

Nutrient Use in Animal and Cropping systems – Efficiencies and Scales framework (NUANCES)

NUANCES was presented by Giller et al. (2011) on the basis of works by Giller et al. (2006) and continues further developments based on results from field experiences and experiments (Rufino et al. 2007; Tittonell et al. 2007; van Wijk et al. 2009; Tittonell et al. 2010). NUANCES assesses the impact and trade-offs of agricultural management and explores the potentials of best-fit technologies and promising management alternatives at farm level before they are promoted to farmers. Different analytical methods are combined, such as participatory research, farm typologies, data-mining, experiments and modeling. NUANCES outlines a four step approach:

1. Describe and group farming systems and constraints (socioeconomic, institutional, agro-ecological data and farming system descriptions).
2. Describe the consequences of farmers' decisions regarding resource allocation: detailed farm descriptions are entered into different models (FARMSIM, FIELD, LIVSIM, HEAPSIM (Giller et al. 2011)) in combination with secondary data, expert knowledge and experiments. The key processes of the farms are described.
3. Draw future scenarios. Here, a series of agro-technologies to improve productivity and trade-offs between resource allocation are discussed.
4. Elaborate with farmers and agents of new management systems that are contributing to sustainable smallholder agriculture. The farmers weigh their farming strategy priorities and plan the interventions.

Response-Inducing Sustainability Evaluation (RISE)
RISE was developed by the School of Agricultural, Forest and Food Sciences (HAFL, www.hafl.bfh.ch) (Grenz et al. 2012). A previous version of the tool for holistic sustainability assessment at farm level was presented by Häni et al. (2003). RISE is an indicator and interview-based method for assessing the sustainability of farm management that considers the economic, social and environmental dimensions. Grenz et al. (2012) define sustainable agriculture as follows: "The farm produces food, feed and further agricultural products and services in amounts and qualities that meet the demands of population and trade and that reflect the local production potential, as defined by climate, soils and socio-economic framework conditions".

All sustainability dimensions (ecologic, economic and social) are covered by 10 indicators (soil use, animal husbandry, nutrient flow, water use, energy & climate, biodiversity & plant production, working conditions, quality of life, economic viability and farm management). Each indicator is calculated from four to seven parameters. According to Häni et al. (2003), for each indicator the current situation "state" (S) and the pressure "driver" (D) that the farming system puts on the indicator are identified. The "Degree of Sustainability" is calculated by the equation "DS = S–D" to identify the strong and weak aspects of the farm. RISE is used for the comparative evaluation of the sustainability degree of different farms, and for the enhancement of the sustainability level of a certain farm. Since the year 2000, RISE has been used on more than 1000 farms worldwide. It has been applied in 36 countries on various farm types from large commercial farms in Europe to smallholder farms in developing countries. The steps of application are:

1. A trained agronomist performs a field visit to the farm and collects data by filling in the RISE questionnaire.
2. Data are entered into the RISE 2.0 software (can be used online and offline, available at: http://www.farmrise.ch) and the degree of sustainability is calculated and visualized in a sustainability polygon.
3. Four dimensions are assessed on three scales, namely whether they are *strong*, *acceptable* or *not favorable* for sustainable development. The four dimensions are: a) stability of the social, economic and ecological framework, b) farmer's risk awareness, attitudes and management,

c) gray energy (machines, buildings, external inputs), and d) animal health and welfare (Häni et al. 2003).

4. The final results are discussed with the farmers or technical advisors to develop management practices that will add to the sustainability of the farm.

Interactive Multi-goal Agro-ecological Generation and Evaluation of Systems (Farm-Images)
The methodological procedure of Farm-Images was presented by Dogliotti et al. (2005). The approach is generic. It integrates complex crop rotations and spatial heterogeneity on farms in one method to support the re-design of farming systems. The method explores sustainable development options and trade-offs at the farm level. It can design a diversity of land-use alternatives describing entire crop rotations based on given criteria. The model creates alternative farm systems by allocating production activities to different land units within a farm while taking into account the socio-economic and environmental objectives as well as the specific production conditions (i.e. land, labor, capital, machinery and irrigation) and the farmer's preferences (i.e. type of crops, rotation length and number of land-use types). The approach follows the steps:

1. Field scale design: A list of crops suitable to be grown at field scale in the case study site is elaborated. These crops are combined in crop rotations with the help of the computer model ROTAT (Dogliotti et al. 2003). The crop rotations are then combined with production techniques. This results in a number of production activities and land-use options at field scale. Coefficients are quantified for each production activity related to their economic performance, resource requirement and impact on the environment.
2. Farm scale design: The optimal production activities identified at field scale are used to produce optimal farm systems that take into account the farmer's resource endowment limitations in the region. Farming systems are designed by optimally allocating production activities to different fields on the farm using the model Farm-Images (Dogliotti et al. 2005). The "[…] model has seven alternative objective functions: farm gross margin, family income, capital requirement, soil erosion, soil organic matter rate, N surplus and environmental exposure to pesticides" (Dogliotti et al. 2006). These functions can be defined as constraints or objectives. Functions that are not required in the study can be left out. Farm-Images gives optimal combinations for each farm, satisfying the farmer's interest and minimizing the negative side effects.
3. The farm types are categorized and are required to represent the diversity of farm types existing in the case-study site. From those different farm types, endowment scenarios are constructed to study the influence of resource availability on options of sustainable farm development. The scenarios are based on the objective function and the sustainability thresholds set.

Tradeoff Analysis Model for Multi-Dimensional Impact Assessment (TOA-MD)
TOA-MD 5.0 is a computerized model publicly available at http://tradeoffs.oregonstate.edu. It was developed by Antle and Valdivia (2006) and further developed and applied in several case studies (Claessens et al. 2008; Antle 2011; Tran et al. 2013). The approach addresses the economic, environmental and social impacts of agricultural technologies, and also assesses adoption rates. The model allows for a quantitative analysis of agricultural systems. The data that is introduced in the model is mainly based on existing secondary, quantitative data derived from existing studies. Additional or missing data is collected during a farm survey. The model can be flexibly set up to calculate a variety of indicators. Any quantifiable outcome variable can be used, for instance

environmental variables like water quality or the amount of protein consumed per household member. The model can simultaneously calculate four outcomes in addition to income and poverty indicators, which are built into the model. It is possible to model whole farm systems, simulate economic indicators and farmer's participation, trade-offs of technology adoption, as well as mean and threshold indicators for any other quantifiable economic, environmental or social outcome of the agricultural system. Assumptions are set for the case-study side during the model's calculations, i.e. the interest of farmers to obtain the highest economic returns.

4. Comparative analysis and discussion of methodological approaches

The 10 methods described above present a variety of methodological approaches that are applied for the assessment of sustainability in crop-farming development projects. They range from quantitative modeling approaches (NUANCES, Farm Images, TOA-MD) over indicator/interview-based approaches (PIA, ScalA, RISE) to more participative frameworks (FoPIA, PIPA, MESMIS, DESIRE-DSS).

4.1 General application characteristics

The methodological approaches vary regarding their initial point of observation. FoPIA, DESIRE-DSS, MESMIS, RISE, NUANCE and Farm-Images start by analyzing the local context and challenges. Based on the current state of farm management, development initiatives are planned to achieve improved sustainability (Table 1). PIA, PIPA, ScalA and TOA-MD take as the initial point of observation an intended development initiative and assess its future impacts from there. The ex-ante impact assessment methods are applied in various thematic agricultural sectors (Table 1), for instance PIA focuses on poverty reduction, FoPIA assesses the sustainability of land-use policies, and ScalA analyzes the scaling-up potential of sustainable crop production. Six of the ten approaches are exclusively used for ex-ante assessments, while PIPA, PIA, MESMIS and TOA-MD can also be applied for monitoring and ex-post analysis. The majority of approaches make use of a method mix, i.e. of qualitative as well as of quantitative analysis practices (PIA, FoPIA, DESIRE-DSS, MESMIS, ScalA and NUANCES). PIPA uses only qualitative data while the modeling approaches RISE, Farm-Images and TOA-MD work only quantitatively. The level of application and spatial scale of impact interpretation greatly varies between the approaches. Particularly, the models Farm-Images and RISE give information at a farm level, while other approaches may also interpret impact outreach at a wider local (village) to regional level (for instance DESIRE-DSS, ScalA, FoPIA). The time needed for the application of the methodological procedures varies because it depends on the scale of the analysis (farm level, village level or regional level). While RISE is assumed to only take two days for an analysis at the farm level, DESIRE-DSS needs about three months for an assessment at the regional level. The majority of approaches presented are applied by research-institutes. PIA, which was developed by the OECD, is widely applied by donor and technical agencies and advisors. Only a few of the methods, such as RISE, are frequently used by implementing institutions.

The end user of the results also varies. Some methods foresee that the results of the analysis are discussed with the farmers and decision makers (for instance FoPIA, DESIRE-DSS, MESMIS, PIPA, RISE), who form the actual target group for finding solutions in a participative way. Others instead use the results for internal decision as to whether projects will be implemented, or how they will have to be modified in order to reach the set sustainability objectives (for instance PIA and ScalA). The time horizons used to project impacts into the future vary from method to method. While NUANCES interprets short-term impacts of one season and longer-term impacts of between 5-10 years, for DESIRE-DSS the short-term impacts are interpreted as lying within 1-3 years and long-term impacts up to 10 years. Some methods, such as FoPIA, PIA and MESMIS do not specify, but note only that the impact assessment focuses on short- and long-term impacts. Time horizons of impacts can vary for different interventions and sustainability dimensions, but in the assessment process, they have to be more accurately defined in order to gain improved estimations of impacts, which vary considerably along the time scale (Table 1).

4.2 Stakeholder involvement and learning

The involvement of stakeholders is a central aspect of sustainability impact assessment, and this involvement is not limited to consultation and information, but includes providing local stakeholders with the capacity to shape decisions (O'Faircheallaigh and Howitt 2013; Stoeglehner and Neugebauer 2013). “In terms of sustainability outcomes, it is critical that voices representing affected economic, environmental, cultural and social values and interests are heard, accurately and fully […]” (O'Faircheallaigh and Howitt 2013). The level of stakeholder involvement varies considerably in the methodological procedures presented (Table 1). DESIRE-DSS, MESMIS, PIPA and FoPIA foresee active participation of multiple-level stakeholder representatives at several stages of the assessment procedure. They are involved to describe the context, define the challenges, elaborate and weigh sustainability indicators, evaluate the intended activities, and in the final decision process on what to implement. These methods base their analysis mainly on primary data collected in the field.

Other methods involve stakeholders during context analysis and in discussions and decision-making after the assessment process (NUANCES, RISE). In PIA, ScalA, NUANCES, RISE, Farm-Images and TOA-MD the sustainability indicators are predetermined and based on theoretical assumptions of sustainable development. Farm-Images at its current stage and TOA-MD foresee little to no involvement of stakeholders. TOA-MD is mainly based on expert estimations and secondary data. In restrictive terms, those approaches (PIA, ScalA, NUANCES, RISE, Farm-Images and TOA-MD) cannot be considered true forms of sustainability impact assessment as defined by Gibson (2013). To contribute to the improvement of sustainable livelihoods, it is necessary to address the needs of the target group. Reductionist approaches with predefined sustainability criteria (for instance RISE, Farm-Images, ScalA) simplify but also dictate what “sustainability” means and neglect the local perspective and development priority, while a more holistic approach (DESIRE-DSS, PIPA, MESMIS, FoPIA) allows the stakeholders to define their own priorities and understanding of sustainability within the local context. Stoeglehner and Neugebauer (2013) emphasize the need of participation and collective learning as central features of sustainability impact assessment, allowing for learning about facts and values within groups of relevant decision makers, stakeholders and planners. Sustainability is not a fixed state, but a moving target. Learning and exchange is an essential element of sustainability assessment (Gibson 2006; Bond et al. 2012; Bond and Morrison-Saunders 2013a, b). Therefore, the learning process is critical for all stakeholders involved. It requires horizontal as well as vertical interaction of multiple level stakeholders (Bond and Morrison-Saunders 2013a). It is therefore not sufficient to involve only one stakeholder group in the impact assessment process, but to integrate stakeholders of different levels, to bring them together for exchange and to involve them from the planning through to the final evaluation stage of an initiative (EIARD 2003; Bond and Morrison-Saunders 2011; Morgan 2012). Only the methodological approaches DESIRE-DSS, FoPIA and PIPA particularly focus on the learning process during the assessment process.

4.3 Sustainability dimensions

Sustainability impact assessment is the only type of assessment that considers and integrates the three pillars of sustainable development (economy, environment and social dimensions) equally while also analyzing the interrelations between the three pillars (Pope et al. 2004; Ness et al. 2007;

Hacking and Guthrie 2008; Bond and Morrison-Saunders 2011; Bond et al. 2012; Singh et al. 2012). All the above-mentioned methodological approaches present an assessment for sustainable development and consider criteria related to all three sustainability dimensions. But not all methodological approaches consider these dimensions in equal terms as required above. NUANCES and Farm-Images mainly focus on economic and environmental criteria. PIA, on the other hand, mainly analyzes the economic and social dimensions. In RISE, the social dimension is under-represented. FoPIA makes use of the land-use functions framework to link regional sustainability issues to land use, which helps to select and assign indicators for each sustainability dimension but recommends restricting them to a feasible number of approximately nine. DESIRE-DSS and MESMIS leave it to the stakeholders to define the nature and number of indicators for each dimension. RISE, PIA, ScalA, NUANCES and Farm-Images predetermine and restrict the number of indicators that are included in the assessment or calculation process. The interrelation between the three dimensions of sustainability are approached in FoPIA, PIPA, DESIRE-DSS and also in MESMIS in a participative way, discussing trade-offs as well as positive implications. The models NUANCES, Farm-Images and TOA-MD calculate trade-offs due to given thresholds, but those are not weighed, strategically discussed or evaluated with the stakeholders. A structured discussion and reflection process with the stakeholders is indispensable for the effective and locally adapted analysis of interrelations.

In all the methodological approaches presented, understanding sustainability involves the consideration of all three dimensions. However, not one of the methodological approaches also factors in the institutional dimension. Sustainability, we argue, has not only three, but four dimensions: social, economic, environmental and institutional (UNDESA 2001; Spangenberg et al. 2002). Institutional capacity is a significant means for facilitating movement towards sustainable development (UNDESA 2001). The Norwegian Agency for Development Cooperation (Norad 2000) defines an institution as sustainable "[…] if it has the strength to survive and develop to fulfil its functions on a permanent basis with decreasing levels of external support". For sustainable development, the involved individuals, organisations and social systems need to increase their capacities and performance in relation to sustainability goals, resources and environment. Core institutional objectives are accountability, civil society empowerment, gender equity and knowledge formation (Spangenberg 2004). Spangenberg (2002) describes the institutional dimension of the sustainability paradigm "[…] as the result of interpersonal processes, such as communication and co-operation, resulting in information and systems of rules governing the interaction of members of a society". Participation and governance are critical elements of the institutional dimension, and are indispensable for sustainable development – particularly in the development context. Institutional criteria and indicators therefore need to be integrated in the sustainability impact assessment framework of development initiatives.

4.4 Intervention planning and sustainable development

Sustainability assessment has the potential to considerably increase the sustainability performance of planning outcomes and decision-making (Bond et al. 2013). Therefore, it should be an integrated step of development initiative planning (Sadok et al. 2008; Stoeglehner and Neugebauer 2013). To date, there has been a lot more focus on the ex-post rather than the ex-ante impact assessment of development initiatives, and currently there is no internationally established standard of methodological approaches to carry out ex-ante sustainability impact assessment on planning development initiatives (GIZ 2013). Both implementing institutions and scientific discourse still has an extensive backlog demand regarding ex-ante impact assessment (Silvestrini 2011).

Figure 2 Challenges for sustainable agricultural development: A Pearl Millet field in an arid area of Tanzania during the main rainy season. Improved yields may enhance the livelihood and the food security of the rural poor population. Ex-ante impact assessment reduces the risks of negative impacts of agricultural development interventions.

A challenge also lies in formulating a common understanding of what impact assessment means. Several institutions and also research reports use the term impact assessment for ex-post evaluation only. But impact assessment is a process that identifies future consequences of an intended action (IAIA 2009) and consequently is part of the planning process of interventions. Several approaches analyzed in this framework did not use the term impact assessment, but decision support. A common understanding of impact assessment in the context of sustainable development therefore is crucial.

5. Conclusion

Ex-ante sustainability impact assessment as part of the planning process is essential for the sustainability of development initiatives. The assessment process respects the three dimensions of the sustainability paradigm. The active involvement of multiple-level stakeholders in the assessment process is crucial to adapting development initiatives to the locally specific conditions. It was the objective of this paper to review, analyze and compare ex-ante sustainability impact assessment methods that are applied within the framework of sustainable agricultural development, with a focus on crop farming in developing countries. We have presented the variety of currently applied methods of ex-ante impact assessment by analyzing a sample of 10 methodological approaches. The minority of methodological approaches analyzed, follow this holistic understanding of sustainability impact assessment. Only those approaches which a) integrate equally all three sustainability dimensions, b) respect their interrelations, c) involve stakeholders actively at every step of the assessment process, and d) also focus on exchange and learning can be considered as a complete or holistic method of sustainability impact assessment. Methodological approaches of sustainability impact assessment have to be adapted to different local contexts and need to respect the requirements mentioned above. Only this kind of ex-ante sustainability impact assessment has a large potential to avoid negative outcomes and to improve stakeholder understanding, acceptance and ownership of the intervention. Therefore, it should be mandatory within the planning process of development initiatives for sustainable development.

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Annexe 2

Pictures of the FoPIA process

Picture 2: Elaboration of locally-relevant food security criteria with a women group in Changarawe, Morogoro

Picture 3: Elaboration of locally-relevant food security criteria with a women group in Changarawe, Morogoro

Picture 4: Elaboration of locally-relevant food security criteria with a men group in Changarawe, Morogoro

Picture 5: Food security criteria scoring results of one workshop group in Changarawe, Morogoro

Picture 6: Moderated discussion on the food security scoring results in a common session with female and male participants

Picture 7: Moderated food security criteria discussion with male and female farmers in Ilakala, Morogoro; Researcher remains in the background and observes the process

Picture 8: Food security criteria elaboration with male focus group in Ilolo, Dodoma

Picture 9: Food security criteria presentation in a common presentation with male and female workshop participants as well as village elders and decision-makers in Idifu, Dodoma

Picture 10: Presentation and explanation of the agricultural upgrading strategies to farmers in Ilakala, Morogoro

Picture 11: Presentation of results of a simplified SWOT analysis of upgrading strategies by smallholders

Picture 12: Selection of priority upgrading strategies for implementation by male farmer in Ilolo, Dodoma

Picture 13: Selection of priority upgrading strategies for implementation by female farmer in Ilolo, Dodoma

Picture 14: Noting down the secret impact assessment scoring results of each farmer by researcher

Picture 15: Presentation of impact assessment results after secret scoring round in Changarawe, Morogoro

Picture 16: Presentation of impact assessment results after secret scoring round in Changarawe, Morogoro

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